Chapter 4:

MECH

Mechanical Systems

4.0 CHAPTER OVERVIEW

This chapter summarizes the requirements for space-conditioning, ventilating and service water-heating systems. Section 4.1 introduces the approaches and concepts of mechanical system compliance with the Energy Efficiency Standards (*Standards*)*.* The Mechanical Design Procedures, section 4.2, covers the mandatory, prescriptive and performance requirements for mechanical systems. For the convenience of designers, a summary of the most important requirements for many of the major heating, ventilating and air

Chapter Contents

4.1 Introduction 4-2
4.1.1. Mechanical Compliance Approaches 4-2
4.1.2. Basic Mechanical Concepts 4-3
A. Definitions of Efficiency 4-3
B. Definitions of Spaces and Systems 4-4
C. Types of Air 4-5
D. Air Deliver System 4-6
E. Attics and Return Plenums 4-6
F. Zone Reheat, Recool and Air Mixing 4-6
G. Economizers 4-7
H. Unusual Sources of Contaminants 4-8
I. Demand Control Ventilation 4-8
J. Intermittently Occupied Spaces 4-8
4.2 Mechanical Design Procedures 4-9
4.2.1 Mandatory Measures 4-9
A. Equipment Certification 4-9
B. Control Equipment Certification 4-10
C. Pilot Lights 4-10
D. Outdoor Ventilation 4-10
E. Natural Ventilation 4-11
F. Mechanical Ventilation 4-12
G. Ventilation System Operation and Controls 4-16
H. Required Controls for Space Conditioning Systems 4-21
I. Requirements for Pipe Insulation 4-26
J. Requirements for Ducts and Plenums 4-28
K. Service Water Systems 4-29
L. Pool/Spa Heating Systems 4-31
4.2.2 Prescriptive Approach 4-31
A. Sizing/Equipment Selection 4-31
B. Load Calculations 4-32
C. Fan Power Consumption 4-34
D. Space-conditioning Zone Controls 4-37
E. VAV Zone Controls 4-38
F. Economizers 4-38
G. Supply-Air Temperature Reset Control 4-40
H. Electric Resistance Heating 4-41
I. Service Water Heating 4-41
4.2.3 Performance Approach 4-41
A. Compliance with a Computer Method 4-42
B. Modeling Mechanical System Components 4-42
4.2.4 Alterations/Additions 4-42
4.2.5 Application to Major Systems Types 4-42
4.3 Mechanical Plan Check Documents 4-57
4.3.1 MECH-1: Certificate of Compliance 4-57
4.3.2 MECH-2: Mechanical Equipment Summary 4-69
4.3.3 MECH-3: Mechanical Ventilation 4-75
4.3.4 MECH-4: Mechanical Sizing and Fan Power 4-78
4.4 Mechanical Inspection 4-82

conditioning (HVAC) systems types is included at the end of this section. The Mechanical Plan Check, section 4.3, describes the information that must be included in the building plans and specifications to show compliance with the Standards including a presentation and discussion of the mechanical compliance forms. The Mechanical Inspection, section 4.4, refers to the Inspection Checklist in Appendix I identifying the items that the inspector will verify in the field.

4.1 INTRODUCTION

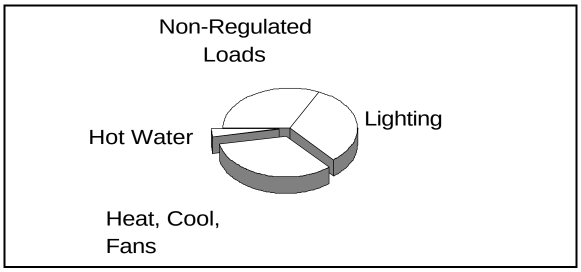


Figure 4-1: Typical Building Energy Use (Energy Efficiency Report, October, 1990, California Energy Commission Publication No. 400-90-003)

Mechanical systems are the second largest consumer of energy in most buildings, exceeded only by lighting. The proportion of space-conditioning energy consumed by various mechanical components varies according to system design and climate. For most buildings in nonmountainous California climates, fans or cooling equipment may be the largest consumer of energy. Space-heating energy is usually less than fans and cooling, followed by service water heating.

The objective of the *Standards* requirements for mechanical systems is to reduce energy consumption while maintaining occupant comfort. These goals are achieved by:

1. Maximizing equipment efficiency, both at design conditions as well as during part load operation

2. Minimizing distribution losses of heating and cooling energy

3. Optimizing system control to minimize unnecessary operation and simultaneous usage of heating and cooling energy

The *Standards* also recognize the importance of indoor air quality for occupant comfort and health. To this end, the *Standards* incorporate requirements for outdoor air ventilation which must be maintained during all operating conditions.

4.1.1. Mechanical Compliance Approaches

After the mandatory measures are met, the *Standards* allow mechanical system compliance to be demonstrated through prescriptive or performance requirements.

Mandatory measures (Sections 110-119 and 120-129) apply to all systems, whether the designer chooses the prescriptive or performance approach to compliance. Mandatory measures include:

1. Certification of equipment efficiency

2. Ventilation requirements

3. Thermostats, shut-off control and night setback/setup

4. Area isolation

5. Duct work construction and insulation

6. Pipe insulation

7. Service water heating and pool heating

Prescriptive measures cover items that can be used to qualify components and systems on an individual basis and are contained in Section 144. Prescriptive measures provide the basis for the *Standards* and are the prescribed set of measures to be installed in a building for the simplest approach to compliance. Prescriptive measures include:

1. Load calculations, sizing, system type and equipment selection Section 144(a) and (b))

2. Fan power consumption (Section 144(c))

3. Controls to reduce reheating, recooling and mixing of conditioned air streams; supply air reset; and variable air volume (VAV) box minimum position (Section 144(d) and (f))

4. Economizers (Section 144(e))

5. Restrictions on electric-resistance heating (Section 144(g))

The **Performance** approach (Section 141) allows the designer to increase the efficiency or effectiveness of selected mandatory and prescriptive measures, and to decrease the efficiency of other prescriptive measures. The performance approach requires the use of an Energy Commission certified computer program, and may only be used to model the performance of mechanical systems that are covered under the building permit application. (See Sections 2.2 and 6.1 for more detail.)

4.1.2. Basic Mechanical Concepts

This section presents definitions and key concepts that apply to mechanical systems. Definitions in italics are quoted from Section 101(b). Other definitions and concepts are not officially part of the *Standards*, but are included here as an aid in understanding the sections that follow.

A. Definitions of Efficiency

Section 111-112 mandate minimum efficiency requirements which regulated appliances and other equipment must meet. These efficiency requirements are listed in Table B-9 in Appendix B. The following describes the various measurements of efficiency used in the *Standards.*

The purpose of space-conditioning and water-heating equipment is to convert energy from one form to another, and to regulate the flow of that energy. Efficiency is a measure of how effectively the energy is converted or regulated. It is expressed as the ratio:

$$Efficiency = \frac{Output}{Input}$$

The units of measure in which the input and output energy are expressed may be either the same or different, and vary according to the type of equipment. The *Standards* use several different measures of efficiency.

Annual Fuel Utilization Efficiency (AFUE) *is a measure of the percentage of heat from the combustion of gas or oil which is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations or Section112, Table 1-C.* The AFUE is usually lower than thermal efficiency because it takes into account the effects of equipment cycling or modulation at loads than design. It is calculated using a prescribed annual load profile.

Coefficient of Performance (COP)**, Cooling**, *is the ratio of the rate of net heat removal to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section112*.

$$COP = \frac{(Cooling\ Output\ Btu / hr)}{(Electric\ Input\ Btu / hr)}$$

As electricity is normally measured in Watts, electric input must be converted to Btu/hr.

Coefficient of Performance (COP)**, Heating**, *is the ratio of the rate of net heat output to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.*

$$COP = \frac{(Heating\ Output\ Btu / hr)}{(Electric\ Input\ Btu / hr)}$$

Combustion Efficiency is not defined in the *Standards*, but is used as the efficiency measurement for large boilers and service water heaters. It is a measure of the percent of energy transfer from the fuel to the heat exchanger (HX). Input and output energy are expressed in the same units so that the result has nondimensional units:

$$\% \ Combustion\ Eff = \frac{(Energy\ to\ HX)}{(Total\ Fuel\ Input)}$$

NOTE:

Combustion efficiency does not include losses from the boiler jacket. It is strictly a measure of the energy transferred from the products of combustion, and is determined directly by a fuel gas analysis.

Energy Efficiency Ratio (EER) *is the ratio of net cooling capacity (in Btu/hr) to total rate of electrical energy (in watts), of a cooling system under designated operating conditions, as determined using the applicable test method in the Appliance Efficiency Regulations or Section112*. An EER is typically used for larger packaged air conditioning equipment to express equipment efficiency. It is similar to IPLV.

$$EER = \frac{(Cooling\ Btu\ /\ hr)}{(Electric\ Input\ Watts)}$$

EER and COP are actually measurements of the same process, but are expressed in different units. They are related as:

$$COP = \frac{EER}{(3.413\ Btu\ /\ Watt)}$$

Energy Factor (EF) *is the ratio of energy output to energy consumption of a water heater, expressed in equivalent units, under designated operating conditions over a 24-hour use cycle, as determined using the applicable test method in the Appliance Efficiency Regulations.* It includes both the thermal efficiency of the heating process, as well as standby losses.

Fan Power Index is the hourly power consumption of the fan system per unit of air moved (Watts per cfm).

Integrated Part Load Value (IPLV) *is a single number of merit based on part load EER or COP expressing part load efficiency for air-conditioning and heat-pump equipment on the basis of weighted operation at various load capacities for the equipment as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112* . It is meant to approximate the ‘typical’ or annual operating efficiency of the equipment, much as an AFUE is used for heating equipment.

Seasonal Energy Efficiency Ratio (SEER) *means the total cooling output of a central air conditioner in British thermal units during its normal usage period for cooling divided by the total electrical energy input in watt-hours during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations*

Thermal Efficiency is defined in the *Appliance Efficiency Regulations* as *a measure of the percentage of heat from the combustion of gas which is transferred to the water as measured under test conditions specified. . .* This definition applies to gas water heaters. In the *Standards*, this definition is generalized to include warm air furnaces.

$$\% \ Thermal\ Eff = \frac{(Energy\ to\ Medium)}{(Total\ Fuel\ Input)}$$

B. Definitions of Spaces and Systems

The concepts of spaces, zones, space-conditioning systems and systems are discussed in this subsection.

Spaces are not formally defined in the *Standards*, but are considered to be areas that are physically separated from each other with walls or other barriers. From a mechanical perspective, the barriers act to inhibit the free exchange of air with other spaces. The term “space” may be used interchangeably with “room.”

Zone, Space Conditioning *is a space or group of spaces within a building with sufficiently similar* *comfort conditioning requirements so that comfort conditions, as specified in Section 144(b)3 or Section 150(h), as applicable, can be maintained throughout the zone by a single controlling device.* It is the designer's responsibility to determine the zoning; in most cases each building exposure will consist of at least one zone. Interior spaces that are not affected by outside weather conditions usually can be treated as a single zone.

A building will generally have more than one zone. For example, a facility having 10 spaces with similar conditioning that are heated and cooled by a single space-conditioning unit using one thermostat, is one zone. However, if a second thermostat and control damper, or an additional mechanical system, is added to separately control the temperature within any of the 10 spaces, then the building has two zones.

A **Space Conditioning System** *is a system that provides either collectively or individually heating, ventilating, or cooling within or associated with conditioned spaces in a building.* Exhaust fans are considered part of a space-conditioning system if they do not serve a process within the building, and are necessary for the proper operation of the space-conditioning system. Toilet exhausts are also included.

A space-conditioning system consists of only the components that must function together to deliver air to a given area; fans that can operate independently of each other comprise separate space-conditioning systems. For example, a building conditioned by 20 four-pipe fan coil units has 20 space-conditioning systems. If, instead, the building were supplied by a central fan system consisting of a supply fan, return fan and economizer, the building would have one space-conditioning system.

If more than one fan shares common air-controlling elements, then they are considered a single space-conditioning system. For example, if two supply fans share a common return fan and economizer, then both supply fans are part of the same space-conditioning system. Separate space-conditioning systems may share a common plenum and/or airshaft. For example, the four-pipe systems cited above may take air from a common plenum.

A **System** is a combination of equipment, controls, accessories, interconnecting means or terminal elements by which energy is transformed to perform a specific function, such as space conditioning, service water heating or lighting.

In the mechanical section, the term "system" will generally refer to one or more space-conditioning systems that are provided with heating and/or cooling energy by central boilers or chillers. As such, a building may have more than one system, and each system may include more than one space-conditioning system. The determining factor is whether any equipment is shared. For example, consider a building having four self-contained packaged rooftop units. This building has four space-conditioning systems, and four systems. If, however, the units were provided with hot and/or chilled water from a single central plant, then the building would have four space-conditioning systems, but only one system

C. Types of Air

Exhaust Air is air being removed from any space or piece of equipment and conveyed directly to the atmosphere by means of openings or ducts. The exhaust may serve specific areas, such as toilet rooms, or may be for a general building relief, such as an economizer.

Make-up Air is air provided to replace air being exhausted.

Mixed Air is a combination of return air and outdoor air. The outdoor air may be introduced to meet outdoor ventilation requirements, or to reduce mechanical cooling when the outdoor air conditions are suitable (see Section 4.1.2G).

Outdoor Air (Outside Air) *is air taken from outdoors and not previously circulated in the building.* For the purposes of ventilation, outdoor air is used to flush out pollutants produced by the building materials, occupants and processes. To ensure that all spaces are adequately ventilated with outdoor air, the

Standards require that each space be adequately ventilated (see Section 4.2.1D).

Return Air is air from the conditioned area that is returned to the conditioning equipment for reconditioning. The air may return to the system through a series of ducts, or through plenums and airshafts.

Supply Air is air being conveyed to a conditioned area through ducts or plenums from a heat exchanger of a heating, cooling, absorption or evaporative cooling system. Supply air is commonly considered air delivered to a space by a space-conditioning system*.* Depending on space requirements, the supply may be either heated, cooled or neutral.

Transfer Air is a way of meeting the ventilation requirements for spaces with different outdoor air requirements by allowing air to transfer from one space to another (see Section 4.2.1F).

D. Air Delivery Systems

Space-conditioning systems can be grouped according to how the airflow is regulated.

Constant Volume System is a space-conditioning system that delivers a fixed amount of air to each space*.* The volume of air is set during the system commissioning.

Variable Air Volume (VAV) System *is a space conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served.* This system delivers conditioned air to one or more zones. The duct serving each zone is provided with a motorized damper that is modulated by a signal from the zone thermostat.

Pressure Dependent VAV Box has an air damper whose position is controlled directly by the zone thermostat. The actual airflow at any given damper position is a function of the air static pressure within the duct. Because airflow is not measured, this type of box cannot control to either a maximum or minimum airflow.

Pressure Independent VAV Box has an air damper whose position is controlled on the basis of measured airflow. The setpoint of the airflow controller is, in turn, reset by a zone thermostat. A maximum and minimum airflow is set in the controller, and the box modulates between the two according to room temperature. Typically, when the zone temperature is at setpoint, the airflow will be halfway between the maximum and minimum airflow settings.

E. Attics and Return Plenums

Attics are unoccupied, unconditioned space located above the conditioned spaces, and outside of the insulated building envelope. Attics are usually closer to outdoor temperature than conditioned space temperature.

Return Air Plenum is an unoccupied space within the insulated building envelope through which air flows back to the space-conditioning system from the space(s). Return plenums are normally immediately above a ceiling, and below an insulated roof or the floor above. The return air temperature is usually within a few degrees of space temperature.

F. Zone Reheat, Recool and Air Mixing

When a space-conditioning system supplies air to one or more zones, different zones may be at different temperatures because of varying loads. Temperature regulation is normally accomplished by varying the conditioned air supply (variable volume), or by varying the temperature of the air delivered.

Reheat *is the heating of air that has been previously cooled by cooling equipment or systems or an economizer.* A heating device, usually a hot water coil, is placed in the zone supply duct and is controlled via a zone thermostat. Electric reheat is sometimes used, but is severely restricted by the *Standards*.

Recool *is the cooling of air that has been previously heated by space conditioning equipment or systems serving the same building.* A chilled water or refrigerant coil is usually placed in the zone supply duct and is controlled via a zone thermostat. Recooling is much less common than reheating.

Air Mixing consists of dampers regulating the flow of two separate air supplies to each zone, one heated and one cooled. The amount of each supply delivered to the zone is usually regulated by a zone thermostat. Occasionally, a third supply consisting of unconditioned, or “neutral” air, is also used.

G. Economizers

Air Economizer is a ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical cooling [during mild or cool weather].

When the *Standards* require an economizer, the economizer must be integrated into the system so that it is capable of supplying part of the cooling load while the rest of the load is satisfied by the refrigeration equipment. The operation of an integrated air economizer is diagrammed in Figure 4-2. When outdoor air is sufficiently cold, the economizer satisfies all cooling demands on its own. As the outdoor temperature (or enthalpy) rises, or as system cooling loads increase, a point may be reached where the economizer is no longer able to satisfy the entire cooling load. At this point the economizer is supplemented by mechanical refrigeration, and both operate concurrently. Once the outside drybulb temperature (for temperature controlled economizer) or enthalpy (for enthalpy economizers) exceeds that of the return air or a predetermined high limit, the outside air intake is reduced to the minimum required, and cooling is satisfied by mechanical refrigeration only.

Nonintegrated economizers cannot be used to meet the economizer requirements of the prescriptive compliance approach. In nonintegrated economizer systems, the economizer may be interlocked with the refrigeration system to prevent both from operating simultaneously. The operation of a nonintegrated air economizer is diagrammed in Figure 4-3. Nonintegrated economizers can only be used if economizers are not required by the performance compliance.

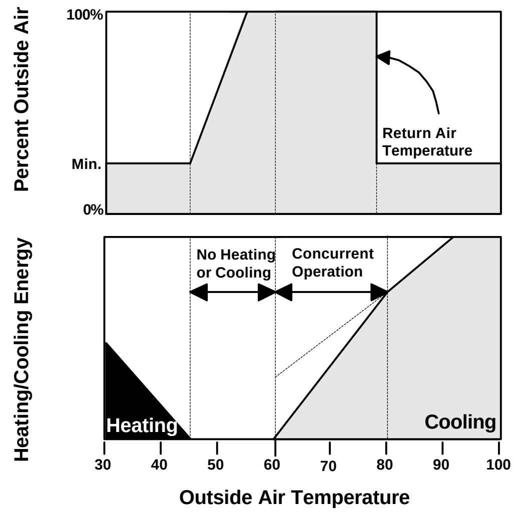


Figure 4-2: Integrated Air Economizer

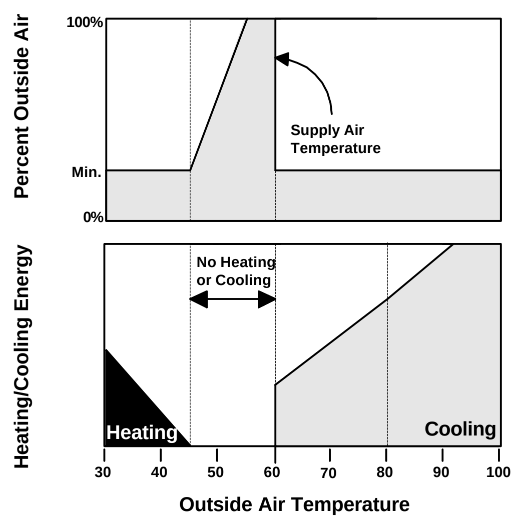


Figure 4-3: NonIntegrated Air Economizer

A **Water Economizer** is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water, or other appropriate fluid, in order to reduce or eliminate the need for mechanical cooling.

As with an air economizer, a water economizer must be integrated into the system so that the economizer can supply a portion of the cooling concurrently with the refrigeration system.

An example of a water economizer is shown in Figure 4.4. In this example, condenser water is cooled by the evaporative cooling tower to 50°F∀ during mild weather, and pumped first through the economizer coil to pre-cool the air. If the air is cooled sufficiently in this manner, the chiller stays off and water is diverted back to the tower. If additional cooling is required, the chiller starts and the air is cooled further, as required. If the weather is such that the tower water is hot (e.g., 75°F), water is diverted around the economizer coil to prevent the air from being heated.

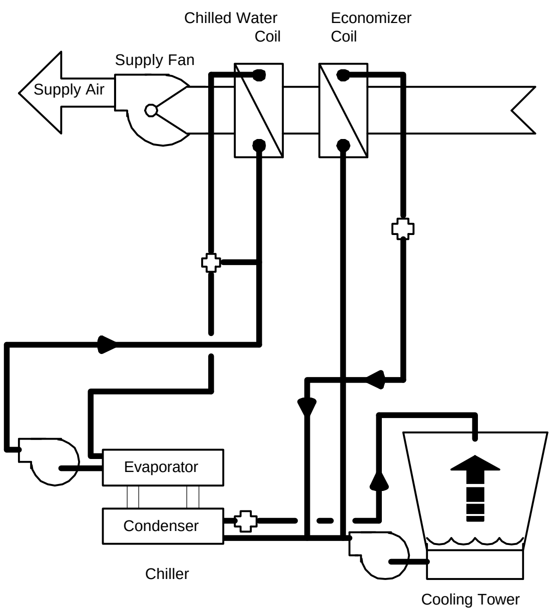


Figure 4-4: Water Economizer

H. Unusual Sources of Contaminants

Section 121 addresses ventilation requirements for buildings and uses the term of "unusual sources of contamination." In this context, such contaminants are considered to be chemicals, materials, processes or equipment that produce pollutants which are considered harmful to humans, and are not typically found in most building spaces. Examples may include some cleaning products, blueprint machines, heavy concentrations of cigarette smoke and chemicals used in various processes.

The designation of such spaces is left to the designer's discretion, and may include considerations of toxicity, concentration and duration of exposure. For example, while photocopiers and laser printers are known to emit ozone, scattered throughout a large space it may not be of concern. A heavy concentration of such machines in a small space may merit special treatment (See Section 4.2.1D)

I. Demand Control Ventilation

Demand control ventilation is allowed as an exception in the ventilation requirements for intermittently occupied systems Section 121(c)1. It is a concept in which the amount of outdoor air used to purge one or more offending pollutants from a building is a function of the measured level of the pollutant(s).

Carbon dioxide sensors measure the level of carbon dioxide, which is the primary pollutant produced by humans and other animals. This is the most common demand control ventilation device, and the only type called out in the *Standards*.

J. Intermittently Occupied Spaces

The demand control ventilation devices discussed above are allowed only in spaces that are intermittently occupied. An intermittently occupied space is considered to be an area which is infrequently or irregularly occupied by people, so that the periods of occupancy cannot be readily determined in advance. Examples may include bars, restaurants, assembly areas, rooms for long-term storage and equipment rooms. Spaces in which normal occupancy can reasonably be determined in advance, such as offices, do not fall in this category.

4.2 MECHANICAL DESIGN PROCEDURES

4.2.1 Mandatory Measures

The mandatory features and requirements for mechanical equipment must be included in the system design whether compliance is shown by the prescriptive or the performance approach. These features have been shown to be cost effective over a wide range of building types and mechanical systems.

It is worth noting that many of the mandatory features and devices, such as equipment efficiency, are requirements of the manufacturer. It is the responsibility of the designer, however, to specify products in the building design that meet these requirements.

Mechanical equipment subject to the mandatory requirements must:

1. Be certified by the manufacturer as complying with the efficiency requirements as prescribed in:

   Section 111 Appliances regulated by the Appliance Efficiency Regulations;

   Section 112 Space Conditioning;

   Section 113 Service Water Heating Systems and Equipment;

   Section 114 Pool and Spa Heating systems and Equipment;

   Section 115 Pilot Lights Prohibited

2. Be specified and installed in accordance with:

   Section 121 Requirements for Ventilation;

   Section 122 Required Controls for Space Conditioning Systems;

   Section 123 Requirements for Pipe Insulation;

   Section 124 Requirements for Ducts and Plenums.

A. Equipment Certification (§111-112)

Mechanical equipment installed in a building subject to these regulations must be certified as meeting certain minimum efficiency and control requirements. These requirements are contained in the Appliance Efficiency Regulations, and are also listed in Appendix B, Table B-9. The AFUE, COP, EER, IPLV, Combustion Efficiency, and Thermal Efficiency values of all equipment must be determined using the applicable test method specified in the Appliance Efficiency Regulations or Section 112:

1. Where more than one efficiency standard or test method is listed, the requirements of both shall apply. For example, both an EER and IPLV are listed for water-cooled air conditioners. This means that the air conditioner must have a rated EER equal to or higher than that specified at Air-Conditioning and Refrigeration Institute (ARI) standard rating conditions, and must also have an annual IPLV equal to or higher than that specified using ARI's assumed operating profiles (Section 112(a)1 & 2).

2. Where equipment can serve more than one function, such as both heating and cooling, or space heating and water heating, it must comply with the requirements applicable to each function.

3. Where a requirement is for equipment rated at its "maximum rated capacity" or "minimum rated capacity," the capacity shall be as provided for and allowed by the controls during steady state operation. For example, a boiler with Hi/Lo firing must meet the efficiency requirements when operating at both its maximum capacity and minimum capacity (Section 112(a)4).

Small appliances such as room air conditioners, gas space heaters and small water heaters, are regulated through the Appliance Efficiency Regulations found in

Title 20, Chapter 2, Subchapter 4, Article 4 of the California Code of Regulations. To comply, manufacturers must certify to the Energy Commission that their equipment meets minimum standards.

Example 4-1: Efficiency Compliance

> ***Question***
>
> *If a gas-pack with 15 tons cooling and 260,000 Btu/hr maximum heating capacity has an EER = 8.7, an IPLV = 7.6 and a heating efficiency of 78 percent, does it comply?*
>
> ***Answer***
>
> *No. The cooling side complies because the EER and IPLV both exceed the requirements. However, the heating efficiency must be at least 80 percent; therefore the unit does not comply. (See Appendix B Table B-9)*

Example 4-2: Efficiency Compliance

> ***Question***
>
> *A 500,000 Btu/hr gas-fired boiler with Hi/Lo firing has a full load combustion efficiency of 82 percent, and a Lo-fire combustion efficiency of 80 percent. Does the unit comply?*
>
> ***Answer***
>
> *Yes. The combustion efficiency is at least 80 percent at both the maximum- and minimum-rated capacity (see Appendix B, Table B-9).*

Larger equipment not covered by the Appliance Efficiency Regulations is regulated by Section 112 of the Standards. To comply, equipment specified in the plans and specifications must meet the minimum standards mandated in that section. Manufacturers of equipment not regulated by the Appliance Efficiency Regulations are not required to certify their equipment to the Energy Commission; it is the responsibility of the designer and contractor to specify and install equipment that complies.

B. Control Equipment Certification (§119(d) & §121(c)1)

In addition to the mechanical equipment discussed above, the following control devices must be certified to the Energy Commission prior to specification or use:

1. **Occupancy Sensors** - per Section 119(d).

2. **Demand Controls Ventilation** - per Section 121(c)1 Exception No. 1.

> NOTE:
>
> Automatic time switches must meet the requirements of Section 119(c). When used solely for mechanical controls they are not required to be certified.

C. Pilot Lights (§115)

Pilot lights are prohibited in:

1. Pool and spa heaters (Section 114(a)5).

2. Household cooking appliances unless the appliance does not have an electrical connection, and the pilot consumes less than 150 Btu/hr (Section 115(b)).

3. Fan type central furnaces. This includes all space-conditioning equipment that distributes gas-heated air through duct work (Section 115(a)). This prohibition does not apply to radiant heaters, unit heaters, boilers or other equipment that does not use a fan to distribute heated air.

D. Outdoor Ventilation - General Requirements (§121)

Ventilation Scope

Within a building all enclosed spaces that are normally used by humans must be continuously ventilated during occupied hours with outdoor air using either natural or mechanical ventilation (Section 121(a)1).

NOTE:

The *Standards* highly recommend that spaces that may have unusual sources of contaminants be designed with enclosures to contain the contaminants, and local exhaust systems to directly vent the contaminants outdoors (Section 121(a)1).

The designation and treatment of such spaces is subject to the designer's discretion. Spaces needing special consideration may include:

- Commercial and coin-operated dry cleaners
- Bars and cocktail lounges
- Smoking lounges and other designated smoking areas
- Beauty and barber shops
- Auto repair workshops
- Print shops, graphic arts studios and other spaces where solvents are used in a process
- Copy rooms, laser printer rooms or other rooms where it is expected that equipment may generate heavy concentrations of ozone or other contaminants

"Spaces normally used by humans" refers to spaces where people can be reasonably expected to remain for an extended period of time. Spaces where occupancy will be brief and intermittent, and that do not have any unusual sources of air contaminants, do not need to be directly ventilated. For example:

1. A **closet** does not need to be ventilated provided it is not normally occupied.
2. A **storeroom** that is only infrequently or briefly occupied does not require ventilation. However, a storeroom that can be expected to be occupied for extended periods for clean-up or inventory must be ventilated, preferably with systems controlled by a local switch so that the ventilation system operates only when the space is occupied.

E. Natural Ventilation (§121(b)1)

Natural outdoor ventilation may be provided for spaces where all areas of the space are within 20 feet of an operable wall or roof opening through which outdoor air can flow. The sum of the areas of the openings must total at least 5 percent of the floor area of each space that is naturally ventilated. The openings must also be readily accessible to the occupants of the space at all times.

Airflow through the openings must come directly from the outdoors; air may not flow through any intermediate spaces such as other occupied spaces, unconditioned spaces, corridors, or atriums. High windows or operable skylights should be accessible from the floor.

Example 4-3: Natural Ventilation

Question

What is the window area required to ventilate a 30' x 32' classroom?

Answer

In order for all points to be within 20 feet of an opening, windows must be evenly divided between two opposing walls. The area of the openings must be:

(32 feet x 30 feet) x 5% = 48 square feet

The actual window area must be at least 96 square feet if only half the window can be open at a time.

Calculations must be based on free area, Taking into account framing, the actual window area is approximately 100 square feet.

F. Mechanical Ventilation (§121(b)2 and (d))

Mechanical outdoor ventilation must be provided for all spaces normally used by humans that are not naturally ventilated. In the discussion that follows, the term *ventilation air* is interchangeable with ‘outdoor ventilation’ or ‘outdoor air.’ *Supply air* means the total amount of air supplied to a space, and includes both recirculated and outdoor air.

Supply Air is air being conveyed to a conditioned area through ducts or plenums from a heat exchanger of a heating, cooling, absorption or evaporative cooling system. Supply air is commonly considered air delivered to a space by a space-conditioning system. Depending on space requirements, the supply may be either heated, cooled or neutral.

Each *space* requiring mechanical ventilation shall be provided with outdoor air at a design rate that is the greater of either Table 4-2 or of the two methods listed below.

Table 4-1a: Minimum Ventilation Rates

Type of Use	CFM / SF Conditioned Floor Area
Auto Repair Workshops	1.50
Barber Shops	0.40
Bars, Cocktail Lounges, and Casinos	1.50
Beauty Shops	0.40
Coin-Operated Cry Cleaning	0.30
Commercial Dry Cleaning	0.45
High Rise Residential	Per UBC Section 1205
Hotel Guest Rooms (< 500 sf)	30 CFM per Guest Room
Hotel Guest Rooms (> or = 500 sf)	0.15
Retail Stores	0.20
Smoking Lounges	1.50
All Others	0.15

1. The **conditioned floor area of the space**, multiplied by the applicable minimum ventilation rate from Table 4-1a.
2. 15 cfm per person, multiplied by the expected number of occupants. For spaces with fixed seating (such as a theater or auditorium), the expected number of occupants as determined in accordance with Chapter 10 of the Uniform Building Code (UBC) is the number of fixed seats. For spaces without fixed seating, the expected number of occupants is assumed to be no less than one-half the maximum occupant load assumed for exiting purposes in Chapter 10 of the UBC. Table 4-1b shows the typical maximum occupant loads for various building uses upon which minimum ventilation calculations are based.

Each *space-conditioning system* must provide outdoor ventilation air as follows:

1. For a space-conditioning system serving a single space, the required system outdoor air flow is equal to the design outdoor ventilation rate of the space.
2. For a space-conditioning system serving multiple spaces, the required outdoor air quantity delivered by the space-conditioning system must be not less than the sum of the required outdoor ventilation rate to each space.

   The *Standards* do not require that each space actually receive its calculated outdoor air quantity (Section 121(b)2 Exception.) Instead, the actual supply to any given space may be any combination of recirculated air, outdoor air, or air transferred directly from other spaces, provided:

   a. The total amount of outdoor air delivered by the space-conditioning system(s) to all spaces is at least as large as the sum of the space design quantities

   b. Each space always receives a supply airflow, including recirculated air and/or transfer air, no less than the calculated outdoor ventilation rate

   c. When using transfer air, none of the spaces from which air is transferred has any unusual sources of contaminants

Table 4-1b: UBC 1997 Occupant Densities (sf/person)

Uniform Building Code Occupant Densities

USE / APPLICATION	OCCUPANT LOAD FACTOR	USE / APPLICATION	OCCUPANT LOAD FACTOR
Aircraft Hangars	500	Courtrooms	40
Auction Room	7	Dormitories	50
ASSEMBLY AREAS		Dwellings	300
Auditoriums	7	Garage Parking	200
Churches/Chapels	7	Healthcare Facilities	
Lobbies	7	Sleeping Rooms	120
Lodge Rooms	7	Treatment Rooms	240
Reviewing Stands	7	Hotel/Apartments	200
Stadiums	7	Kitchens - Commercial	200
Waiting Areas	3	Library	
Conference Room	15	Reading Rooms	50
Dining Rooms	15	Stack Areas	100
Drinking Rooms	15	Locker Room	50
Exhibit Rooms	15	Malls (see UBC chpt.4)	--
Gymnasiums	15	Manufacturing Areas	200
Lounges	15	Mechanical Equipment Rooms	300
Stages	15	Day Care	35
Gaming: Keno, Slot Machine and Live Games Area	11	Offices	100
		School Shops/Vocational Rooms	50
Bowling Alley (assume no occupants for lanes)	5/alley+15ft runway	Skating Rinks	50 Skate Area/ 15 on Deck
Children's Home	80	Storage/Stock Rooms	300
Home for Aged	80	Stores – Retail Sales Room	
Classrooms	20	Basements and Ground Floor	30
Congregate Residences	200	Upper Floors	60
Accommodating 10 or less persons and having an area of 3,000 sq.ft. or less		Swimming Pools	50 Pool Area/ 15 on Deck
		Warehouses	500
		All Others	100

Table 4-2: Required Minimum Ventilation Rate Per Occupancy

Occupancy / Use	UBC Table No. 10-A		Choose Largest		
	Sf/ Occupant	Number of People per 1000 sf	Ventilation CEC STD Table 1-F CFM/sf	UBC Based Ventilation CFM/sf	Req. Vent CFM/sf (largest)
1) Aircraft Hangars	500	2	0.15	0.02	0.15
2) Auction Rooms	7.0	143	0.15	1.07	1.07
3) Assembly Areas (Concentrated Use)					
Auditoriums	7.0	143	0.15	1.07	1.07
Bowling Alleys	4.0	250	0.15	1.88	1.88
Churches & Chapels (Religious Worship)	7.0	143	0.15	1.07	1.07
Dance Floors	7.0	143	0.15	1.07	1.07
Lobbies	7.0	143	0.15	1.07	1.07
Lodge Rooms	7.0	143	0.15	1.07	1.07
Reviewing Stands	7.0	143	0.15	1.07	1.07
Stadiums	7.0	143	0.15	1.07	1.07
Theaters - All	7.0	143	0.15	1.07	1.07
Waiting Areas	3.0	333	0.15	2.50	2.50
4) Assembly Areas (Nonconcentrated Use)	15.0	67	0.15	0.50	0.50
Conference & Meeting Rooms (1)	15.0	67	0.15	0.50	0.50
Dining Rooms/Areas	15.0	67	0.15	0.50	0.50
Drinking Establishments (2)	15.0	67	1.50	0.50	1.50
Exhibit/Display Areas	15.0	67	0.15	0.50	0.50
Gymnasiums/Sports Arenas	15.0	67	0.15	0.50	0.50
Lounges	15.0	67	1.50	0.50	1.50
Stages	15.0	67	1.50	0.50	1.50
Gaming, Keno, Slot Machine and Live Games Areas	11.0	91	1.50	0.68	1.50
5) Auto Repair Workshops	100.0	10	1.50	0.08	1.50
6) Barber & Beauty Shops	100.0	10	0.40	0.08	0.40
7) Children's Homes & Homes for Aged	80.0	13	0.15	0.09	0.15
8) Classrooms	20.0	50	0.15	0.38	0.38
9) Courtrooms	40.0	25	0.15	0.19	0.19
10) Dormitories	50.0	20	0.15	0.15	0.15
11) Dry Cleaning (Coin-Operated)	100.0	10	0.30	0.08	0.30
12) Dry Cleaning (Commercial)	100.0	10	0.45	0.08	0.45
13) Garage, Parking	200.0	5	0.15	0.04	0.15
14) Healthcare Facilities: Sleeping Rooms	120.0	8	0.15	0.06	0.15
Treatment Rooms	240.0	4	0.15	0.03	0.15
15) Hotels and Apartments	200.0	5	0.15	0.04	0.15
Hotel Function Area (3)	15.0	67	0.15	0.50	0.50
Hotel Lobby	100.0	10	0.15	0.08	0.15
Hotel Guest Rooms (<500 sf)	200.0	5	Footnote 4	0.04	Footnote 4
Hotel Guest rooms (>=500 sf)	200.0	5	0.15	0.04	0.15
Highrise Residential	200.0	5	0.15	0.04	0.15
16) Kitchen(s)	200.0	5	0.15	0.04	0.15
17) Library : Reading Rooms	50.0	20	0.15	0.15	0.15
Stack Areas	100.0	10	0.15	0.08	0.15
18) Locker Rooms	50.0	20	0.15	0.15	0.15
19) Manufacturing	200.0	5	0.15	0.04	0.15
20) Mechanical Equipment Room	300.0	3	0.15	0.03	0.15
21) Nurseries for Children - Day Care	50.0	20	0.15	0.15	0.15
22) Offices: Office	100.0	10	0.15	0.08	0.15
Bank/Financial Institution	100.0	10	0.15	0.08	0.15
Medical & Clinical Care	100.0	10	0.15	0.08	0.15
23) Retail Stores (See Stores)					
24) School Shops & Vocational Rooms	50.0	20	0.15	0.15	0.15
25) Skating Rinks: Skate Area	50.0	20	0.15	0.15	0.15
On Deck	15.0	67	0.15	0.50	0.50
26) Stores : Retail Sales, Wholesale Showrooms	30.0	33	0.20	0.25	0.25
Basement and Ground Floor	30.0	33	0.20	0.25	0.25
Upper Floors	60.0	17	0.20	0.13	0.20
Grocery	30.0	33	0.20	0.25	0.25
Malls, Arcades, & Atria	30.0	33	0.20	0.25	0.25
27) Swimming Pools : Pool Area	50.0	20	0.15	0.15	0.15
On Deck	15.0	67	0.15	0.50	0.50
28) Warehouses, Industrial & Commercial Storage/Stockrooms (see 4.2.1 b)	500.0	2	0.15	0.02	0.15
29) All Others -- Including Unknown	100.0	10	0.15	0.08	0.15
Corridors, Restrooms, & Support Areas	100.0	10	0.15	0.08	0.15
Commercial & Industrial Work	100.0	10	0.15	0.08	0.15

Footnotes:
1) Convention, Conference, Meeting Rooms
2) Bars, Cocktail & Smoking Lounges, Casinos
3) See Conference Rooms or Dining Rooms
4) Guestrooms less than 500 sf use 30 cfm/guestroom

Equations used to find:

1) $$\text{Number of People per 1000sf} = \frac{1000}{\text{Sf/Occupant}}$$

2) $$\text{UBC Based Ventilation CFM/sf} = \left(\frac{\frac{\text{Number of People per 1000sf}}{1000}}{2}\right) \times 15\ \text{CFM}$$

The concept of transfer and/or recirculated air is very important, because it allows a single space-conditioning system to serve areas requiring different fractions of outdoor air in their supplies. Rather than establishing the outdoor ventilation rate on the basis of the zone requiring the *highest* outdoor air fraction, this exception allows the ventilation rate to be based on the *average* required by all spaces served by the system.

Required ventilation rates for a two-space building are illustrated in Example 4-4. When each space is served by a separate constant volume system, the calculation and application of ventilation rate is straightforward, and each space will always receive its design outdoor air quantity. However, a central system serving both spaces does not deliver the design outdoor air quantity to each space. Instead, one space receives more than its allotted share, and the other less. This is because the training room has a higher design outdoor ventilation rate and/or a lower cooling load relative to the other space. The *Standards* permit this, provided the system meets the requirements described in items 2a, 2b and 2c above.

The *Standards* allow this compromise in recognition of the difficulty in positively ensuring that each space is always ventilated at the design rate, particularly when variable air volume (VAV) systems are used and/or the future location of conference rooms and other tenant improvements are not known. The *Standards* also implicitly recognize that the building will be adequately ventilated in most cases as long as the total system ventilation rate is sufficient.

Example 4-4: Ventilation for a Two-room Building

Question

Consider a building with two spaces, each having an area of 1,000 square feet. One space is used for general administrative functions, and the other is used for classroom training. It is estimated that the office will contain seven people, and the classroom will contain 50 (fixed seating). What are the required outdoor ventilation rates?

Answer

1. *For the office area, the design outdoor ventilation air is the larger of:*

   7 people x 15 cfm/person = 105 cfm

   or

   1,000 sf x 0.15 cfm/sf = 150 cfm

   For this space, the design ventilation rate is 150 cfm.

2. *For the classroom, the design outdoor ventilation air is the larger of:*

   50 people x 15 cfm/person = 750 cfm

   or

   1,000 sf x 0.15 cfm/sf = 150 cfm

   For this space the design ventilation rate is 750 cfm.

Assume the total supply air necessary to satisfy cooling loads is 1000 cfm for the office and 1,500 cfm for the classroom. If each space is served by a separate system, then the required outdoor ventilation rate of each system is 150 cfm and 750 cfm, respectively. This corresponds to a 15 percent outside air (OA) fraction in the office HVAC unit, and 50 percent in the classroom unit.

If both spaces are served by a central system, then the total supply will be (1,000 + 1,500) cfm = 2500 cfm. The required outdoor ventilation rate is (150 + 750) = 900 cfm total. The actual outdoor air ventilation rate for each space is:

Office OA = 900 cfm x (1,000 cfm / 2,500 cfm) = 360 cfm

Classroom OA = 900 cfm x (1,500 cfm / 2,500 cfm) = 540 cfm

While the actual OA cfm to the classroom is less than design (540 cfmvs. 750 cfm), the Standards allow this provided that the system always delivers at least 750 cfm to the classroom (including transfer or recirculated air), and that any transfer air is free of unusual contaminants.

The *Standards* specify the minimum outdoor ventilation rate to which the system must be designed. If desired, the designer may elect to take a more conservative approach. For example, the design outdoor ventilation rate may be determined using the procedures described in ASHRAE 62-1989, provided the resulting outdoor air quantities are no less than required by these *Standards*.

Direct Air Transfer

As described above, the *Standards* allow air to be directly transferred from other spaces as part of the "outdoor" supply to a space. The actual percentage of outdoor air present in the transfer air need not be taken into account as long as the total outdoor quantity required by all spaces is provided by the mechanical system. This method can be used for any space, but is particularly applicable to conference rooms and other rooms that have high ventilation requirements. Transfer air must be free from any unusual contaminants, and as such should not be taken directly from rooms where such sources of contaminants are anticipated.

Air may be transferred using any method that ensures a positive airflow. Examples include dedicated transfer fans, exhaust fans and fan-powered VAV boxes. A system having a ducted return may be balanced so that air naturally transfers into the space. Exhaust fans serving the space may discharge directly outdoors, or into a return plenum. Transfer systems should be designed to minimize recirculation of transfer air back into the space; duct work should be arranged to separate the transfer air intake and return points. When the location of conference rooms and other areas requiring high ventilation rates are known in advance, it is recommended that these spaces be provided with separate sources of outdoor air. Note also that other codes may restrict from where transfer air may be taken. For example, transfer air cannot be drawn from a fire-resistive corridor used for exit purposes. Transfer air can be transported through fire-rated partitions provided all code requirements, such as the use of fire and/or smoke dampers, are met.

Distribution of Outdoor Air to Zonal Units (§121(d))

When a zonal heating or cooling unit is located in a plenum and an outdoor supply is not directly connected to the unit, then the outdoor air must be ducted to discharge either:

1. Within five feet of the unit; or

2. Within 15 feet of the unit, with the air directed substantially toward the unit, and with a discharge velocity of at least 500 feet per minute.

Water source heat pumps and fan coils are the most common application of this configuration. The unit fans should be controlled to run continuously during occupancy in order for the ventilation air to be circulated to the occupied space.

A central space-conditioning system(s) augmented by a few zonal units for spot conditioning may use transfer air from spaces served by the central system. A direct source of outdoor air is not required for each zonal unit. Similarly, transfer air may be used in buildings having central interior space-conditioning systems with outdoor air, and zonal units on the perimeter (without outdoor air).

While not required, the *Standards* recommend that sources of unusual contaminants be controlled through the use of containment systems that capture the contaminants and discharge them directly outdoors. Such systems may include exhaust hoods, fume hoods, small space exhausts and differential pressure control between spaces. The designer is advised to consult ASHRAE handbooks or other publications for guidance in this subject.

G. Ventilation System Operation and Controls (§121(c))

Outdoor Ventilation Air and VAV Systems

The *Standards* require that the minimum rate of outdoor air calculated per Section 121(b)2 be provided to each space *at all times* when the space is usually occupied (Section 121(c)1). For spaces served by VAV systems, this implies that the minimum supply setting of each VAV box should be no less than the design outdoor ventilation rate calculated for the space, unless transfer air is used. If transfer air is used, the minimum box position, plus the transfer air, should meet the minimum ventilation rate. If transfer air is not used, the box should be controlled so that the minimum required airflow is maintained at all times. With either strategy, the box should have pressure-independent controls; pressure dependent controls cannot ensure that ventilation is maintained because they do not measure airflow. See Example 4-5.

The design outdoor ventilation rate at the system level must always be maintained when the space is occupied, even when the fan has modulated to its minimum capacity (Section 121(c)1). Therefore, a means of continuously providing at least the minimum amount of outdoor air should be incorporated into the design of the system. Such means may include:

1. Separate outdoor air fans with modulating controls that introduce a fixed amount of air into the return or mixed air sections of the system; or

2. Controls that maintain a fixed differential between supply and return fan air flow rates. The differential may be measured with air flow stations, or determined during commissioning via an air balance, taking multiple measurements of flow at different fan capacities; or

Example 4-5: Minimum VAV CFM

Question

If the minimum required outdoor ventilation rate for a space is 150 cfm, what is the minimum allowed airflow for a 1000 cfm VAV box when the designed percentage of outdoor air in the supply is 20 percent?

Answer

The ventilation standard requires that every space in a building be designed to have outdoor air ventilation Section 121 (b)). Based on the design criteria, the total circulated air volume in this case will be 750 cfm (150/0.20). However, the outside air supply can be up to 100 percent of the total supply. Additionally, the minimum allowed airflow may be as low as 150 cfm provided that enough outdoor air is supplied to all spaces combined to meet the requirements of Section 121(b)2 for each space individually.

3. Exhaust fans, including toilet exhausts, that exhaust a fixed amount of air from the building during all occupied hours; or

4. Outside air dampers having minimum settings that vary with fan capacity. This will necessitate an air balance taking multiple measurements of outdoor air flow in comparison to fan capacity so that a curve can be developed. A controller capable of being programmed with the curve will be critical, as is some means of measuring fan capacity. Capacity can be measured by an air flow station, or correlated to an inlet vane signal, a variable frequency drive (VFD) signal, or fan motor amps; or

5. Balancing the space-conditioning system to provide the required outdoor ventilation at the minimum expected supply airflow.

   If the space-conditioning system incorporates an air economizer, the balance may be made at the expected supply airflow corresponding to the conditions at which the economizer closes to minimum. For example, assume the economizer closes to minimum at an outdoor temperature of 70°F. Below this temperature, the economizer will usually be delivering more than the minimum outdoor ventilation rate in order to satisfy space cooling loads. Therefore, the operating point of concern for the minimum outdoor damper setting corresponds to the supply airflow normally expected at 70°F.

For systems that do not have a return fan, the actual outdoor ventilation rate will increase as the fan supply increases and the static pressure on the suction side of the fan drops. In this case, the load calculations and equipment sizes as documented on the compliance forms must be based on the outdoor ventilation rate expected at design conditions, and not the minimum as calculated in this section.

Since this approach can force equipment to be larger than otherwise required and may also waste energy, other solutions are preferred; or

6. Provide dedicated intake and supply fans designed to meet minimum ventilation requirements; or

7. Other methods approved by the enforcement agency.

Pre-Occupancy

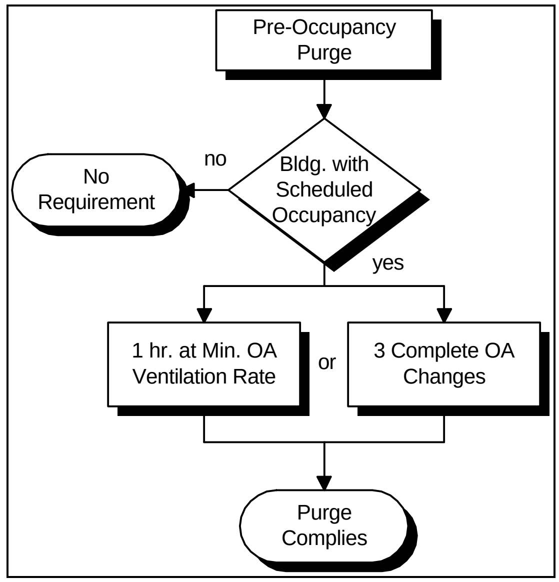
Since many indoor air pollutants are outgassed from the building materials and furnishings, the *Standards* require that buildings having a scheduled operation be purged before occupancy (Section 121(c)2). In the hour immediately prior to occupancy, outdoor ventilation must be provided at a rate equal to the lesser of :

1. The minimum required ventilation rate; or

2. Three complete air changes per hour.

The first criteria will normally apply to office spaces when the outdoor damper is in the minimum ventilation position. The second criteria would apply to spaces having higher ventilation rates, or to offices if the purge is accomplished by using an economizer with dampers fully open. *Three complete air changes* means an amount of ventilation air equal to three times the volume of the occupied space. This air may be introduced at any rate provided for and allowed by the system, so that the actual purge period may be less than an hour.

Figure 4-5: Pre-Occupancy Purge Flowchart



A pre-occupancy purge is not required for buildings or spaces that are not occupied on a scheduled basis, such as storage rooms. Also, a purge is not required for spaces provided with natural ventilation.

Example 4-6: Purge Period

Question

What is the length of time required to purge a space 10 feet high with an outdoor ventilation rate of 1.5 cfm/sf?

Answer

For 3 air changes, each square foot of space must be provided with:

OA volume = 3 x 10 = 30 cubic feet

At a rate of 1.5 cfm/sf, the time required is:

Time = 30 cf / 1.5 cfm/sf = 20 minutes

Example 4-7: Purge with Natural Ventilation

Question
In a building with natural ventilation, do the windows need to be left open all night to accomplish a building purge?
Answer
No. A building purge is required only for buildings with mechanical ventilation systems.

Example 4-8: Purge with Occupancy Timer

Question
How is a purge accomplished in a building without a regularly scheduled occupancy whose system operation is controlled by an occupancy sensor?
Answer
There is no purge requirement for this building. Note that occupancy sensors and manual timers can only be used for system control in buildings that are intermittently occupied.

NOTE:
Many programmable control systems have as part of their standard package a control sequence called *Optimized Start.* This logic will calculate how far in advance of occupancy the HVAC system must start so that the space temperature is at setpoint at time of occupancy. To maximize energy savings, this logic typically keeps the outside air dampers closed until occupancy. Programming in control systems using this logic should be modified to incorporate a building purge in accordance with these requirements

Demand Control Ventilation

As described in Section 121(b)2, outdoor ventilation requirements are based on either a cfm/sf requirement or 15 cfm per person, whichever is larger. If the design occupant density is the determining factor, and the actual number of people is often less than design, then the HVAC system will frequently be conditioning unnecessarily large amounts of outdoor air.

The outdoor ventilation rate in these types of facilities can be reduced by a demand control ventilation device, provided:

1. The device is certified to the Energy Commission; and

2. If the device is a CO_2 sensor, it limits the CO_2 level to no more than 800 parts per million (ppm) while the space is occupied; and

3. The sensor for the device is located either in the space or in the return air from the space, with no less than one sensor for every 25,000 square feet of habitable space, or no more space than is recommended by the manufacturer, whichever is less.

The controls must not allow the effective ventilation rate to drop below 0.15 cfm per square foot.

Examples of suitable applications for demand ventilation controls include restaurants, hotel ballrooms, meeting rooms, lecture halls, etc. Offices and other spaces having occupant densities less than 10 people per 1,000 square feet would not be good applications as the cfm per square foot requirement exceeds the cfm per person requirement.

Fan Cycling

While Section 121(c) requires that ventilation be continuous during normally occupied hours, Exception No. 2 allows the ventilation to be disrupted for not more than five minutes out of every hour. In this case the ventilation rate during the time the system is ventilating must be increased so the average rate over the hour is equal to the required rate.

This restriction limits the duty cycling of fans by energy management systems to not more than five minutes out of every sixty. In addition, when a space-conditioning system that also provides ventilation is controlled by a thermostat incorporating a fan “On/Auto” switch, the switch should be set to the "On" position. Otherwise, during mild conditions, the fan may be off the majority of the time.

Variable Air Volume (VAV) Changeover Systems

Some VAV systems provide conditioned supply air, either heated or cooled, through a single set of ducting. These systems are commonly referred to as "single duct VAV systems." In the event that heating is needed at the same time that cooling is needed in one or more different spaces, the system must alternate between supplying heated and cooled air. When the supply air is heated, for example, the spaces requiring cooling are isolated (cut off) by the VAV dampers and must wait until the system switches back to cooling mode.

Systems of this type do not meet the ventilation requirements unless provisions are incorporated to ensure that the required ventilation to each space is disrupted no more than five minutes every hour. This may require that the controls incorporate a minimum damper position setting for each zone. Alternatively, natural ventilation or other ventilation mechanisms can be provided.

Adjustment of Ventilation Rate

Section 121(c) specifies the minimum required outdoor ventilation rate, but does not restrict the maximum. However, if the designer elects to have the space-conditioning system operate at a ventilation rate higher than the rate required by the *Standards*, then the *Standards* require that the space-conditioning system must be adjustable so that in the future the ventilation rate can be reduced to the amount required by the *Standards* or the rate required for make-up of exhaust systems that are required for a process, for control of odors, or for the removal of contaminants within the space Section 121(e)).

In other words, a system can be designed to supply higher than minimum outside air volumes provided dampers or fan speed can be adjusted to allow no more than the minimum volume if, at a later time, someone decides it is desirable. The *Standards* preclude a system designed for 100 percent outdoor air, with no provision for any return air, unless the supply air quantity can be adjusted to be equal to the design minimum outdoor air volume. The intent is to prevent systems from being designed that will permanently over ventilate spaces.

Miscellaneous Dampers (§122(f))

Dampers should not be installed on combustion air intakes, or where prohibited by other provisions of law (Section 122(f) Exception Nos. 3 & 4). If the designer elects to install dampers on shaft vents to help control stack-induced infiltration, the damper should be motorized and controlled to open in accordance with applicable fire codes.

Completion and Balancing (§121(f))

Before an occupancy permit is granted for a new building or space, or before a new space-conditioning or ventilating system serving a building or space is operated for normal use, the mechanical ventilation system serving the building or space must be documented in accordance with Title 8, Section 5142(b) of the California Safety Code (1987) to be providing no less than the ventilation rate required by the *Standards* as determined using one of the following procedures:

1. Balancing: The system shall be balanced in accordance with the National Environmental Balancing Bureau (NEBB) Procedural Standards (1983), or Associated Air Balance Council (AABC) National Standards (1989); or

2. Outside Air Certification: The system shall provide the minimum outside air as shown on the mechanical drawings, and shall be measured by the installing licensed C-20 mechanical contractor and certified by either the design mechanical engineer, the installing licensed C-20 mechanical contractor, or the person with overall responsibility for the design of the ventilation system; or

3. Outside Air Measurement: The system shall be equipped with a calibrated local or remote device capable of measuring the quantity of outside air on a continuous basis and displaying that quantity on a readily accessible display device; or

4. Another method approved by the Energy Commission.

> NOTE:
>
> Additional code requirements may also apply in some areas of California, such as for the City of Los Angeles. This certification is regarded as “documentation in writing” and becomes the “first record” required by Title 8 of the new building.

Example 4-9: Maintenance of Ventilation System

Question

In addition to these commissioning requirements for the ventilation system, are there any periodic requirements for inspection?

Answer

These Standards do not contain any such requirements. However, Section 5142 of the General Industry Safety Orders, Title 8, California Safety Code (1987): Mechanically Driven Heating, Ventilating and Air Conditioning (HVAC) Systems to Provide Minimum Building Ventilation, states the following:

(b) Operation and Maintenance

(1) The HVAC system shall be inspected at least annually, and problems found during these inspections shall be corrected within a reasonable time.

(2) Inspections and maintenance of the HVAC systems shall be documented in writing. The employer shall record the name of the individual(s) inspecting and/or maintaining the system, the date of the inspection and/or maintenance, and the specific findings and actions taken. The employer shall ensure that such records are retained for at least five years.

(3) The employer shall make all records required by this section available for examination and copying, within 48 hours of a request, to any authorized representative of the Division (as defined in Section 3207 of Title 8), to any employee of the employer affected by this section, and to any designated representative of said employee of the employer affected by this section.

H. Required Controls for Space Conditioning Systems (§122)

This section covers controls that are mandatory for all system types, including:

1. Zoning and thermostatic control,

2. Shut-off and temperature setup/setback of space-conditioning systems, and

3. Off-hours space isolation.
   Zone Thermostatic Control (Section 122(a), (b) and (c))

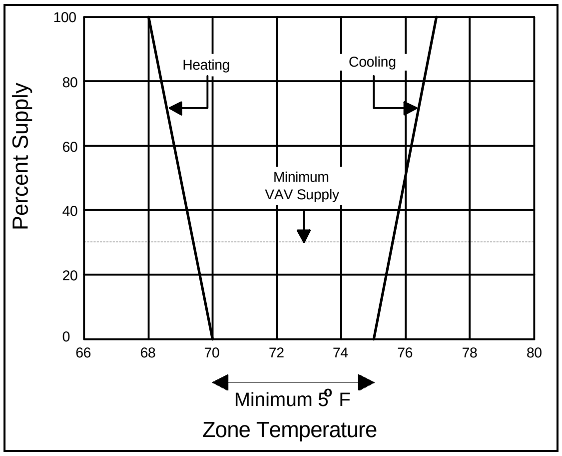
A thermostat must be provided for each *space-conditioning zone* or dwelling unit to control the supply of heating and cooling energy within that zone (Section 122(a)). The thermostat must have the following characteristics:

1. When used to control **heating**, the thermostat must be adjustable down to 55°F or lower.

2. When used to control **cooling**, the thermostat must be adjustable up to 85°F or higher.

3. When used to control both **heating and cooling**, the thermostat must be adjustable
4. from 55°F to 85°F and also provide a temperature range or **dead band** of at least 5°F. When the space temperature is within the deadband, heating and cooling energy must be shut off or reduced to a minimum. A dead band is not required if the thermostat requires a manual changeover between the heating and cooling modes Section 122(b) Exception No. 1).

Figure 4-6: Proportional Control Zone Thermostat



The setpoint may be adjustable either locally or remotely, by continuous adjustment or by selection of sensors.

Example 4-10: Direct Digital Control of Space Temperature

Question
Can an energy management system be used to control the space temperatures?
Answer
Yes, provided the space temperature setpoints can be adjusted, either locally or remotely.

Thermostats with adjustable setpoints and deadband capability are not required for zones that must have constant temperatures to prevent the degradation of materials, a process, or plants or animals Section 122(b) Exception No. 2). Included in this category are computer rooms, clean rooms, hospital patient rooms, museums, etc.

Hotel/Motel Guest Rooms and High-Rise Residential Dwellings Thermostats

The *Standards* require that thermostats in hotel and motel guest rooms have:

1. **Numeric temperature setpoints** in °F, and
2. **Setpoint stops** that prevent the thermostat from being adjusted outside the normal comfort range. These stops must be concealed so that they are accessible only to authorized personnel.

The *Standards* effectively prohibit thermostats having 'warmer/cooler' or other labels with no temperature markings in this type of occupancy (Section 122(c)).

The *Standards* require (Section 122(c)) that thermostats in High-rise residential dwelling units must have setback capabilities and meet all the requirements in Section 150(i).

Perimeter Systems Thermostats

Supplemental perimeter heating or cooling systems are sometimes used to augment a space-conditioning system serving both interior and perimeter zones. Section 122(a) Exception allows this, provided controls are incorporated to prevent the two systems from conflicting with each other. In this case, the *Standards* require that:

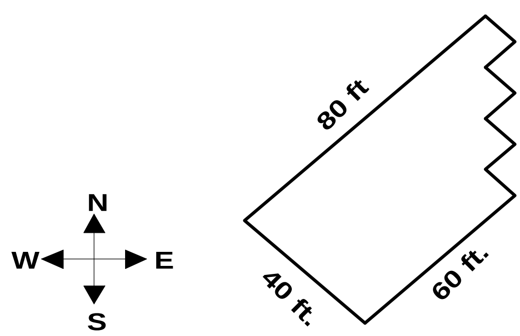
1. The perimeter system must be designed solely to offset envelope heat losses or gains; and
2. The perimeter system must have at least one thermostatic control for each building orientation of 50 feet or more; and
3. The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

The intent is that all major exposures be controlled by their own thermostat, and that the thermostat be located within the conditioned perimeter zone. Other temperature controls, such as outdoor temperature reset or solar compensated outdoor reset, do not meet the requirements of the *Standards*.

Example 4-11: Perimeter Systems Thermostats

Question

What is the perimeter zoning required for the building shown here?



Answer

The southeast and northwest exposures must each have at least one perimeter system control zone, since they are more than 50 feet in length. The southwest exposure and the serrated east exposure do not face one direction for more than 50 continuous feet in length. They are therefore "minor" exposures and need not be served by separate perimeter system zones, but may be served from either of the adjacent zones.

Shut-off and Temperature Setup/Setback (§122(e))

For specific occupancies and conditions, each space-conditioning system must be provided with controls that can automatically shut off the equipment during unoccupied hours. The control device can be either:

1. An *automatic time switch* device must have the same characteristics that lighting devices must have, as described in Section 5.2.1. This can be accomplished with a seven day programmable thermostat with a battery backup of at least ten hours.

   A manual override accessible to the occupants must be included in the control system design either as a part of the control device, or as a separate override control. This override shall allow the system to operate up to four hours during normally unoccupied periods.

2. An *occupancy sensor*. Since a building ventilation purge is required prior to normal occupancy (Section 121(c)2), an occupancy sensor may be used to control the availability of heating and cooling, but should not be used to control the outdoor ventilation system (unless the building is intermittently occupied). In such a case, an automatic time switch should be used instead.

   When an automatic time switch is used to control ventilation while occupancy sensors are used simultaneously to control heating and cooling, the controls should be interlocked so that ventilation can be provided during off-hours operation.

3. A *four-hour timer* that can be manually operated to start the system. As with occupancy sensors, the same restrictions apply to controlling outdoor air ventilation systems.

When shut down, the controls shall automatically restart the system to maintain:

1. A **setback heating thermostat setpoint**, if the system provides mechanical heating. Thermostat setback controls are not required in areas where the Winter Median of Extremes outdoor air temperature is greater than 32°F (Section 122(e)2.A and Exception).

2. A **setup cooling thermostat setpoint**, if the system provides mechanical cooling. Thermostat setup controls are not required in areas where the Summer Design Dry Bulb 0.5 percent temperature is less than 100°F Section 122(e)2.B and Exception).

Example 4-12: Office Occupancy Sensor

Question

Can occupancy sensors be used in an office to shut off the VAV boxes during periods the spaces are unoccupied?

Answer

Not completely. The occupancy sensor could be used to reduce the VAV box airflow to the minimum allowed for ventilation. It should not shut the airflow off completely, because Section 121(c) requires that ventilation be supplied to each space at all times when the space is usually occupied.

Example 4-13: Automatic Time Switches with Multiple Systems

Question

Must a 48,000 square foot building with 35 fan coil units have 35 time switches?

Answer

No. More than one space-conditioning system may be grouped on a single time switch, subject to the area limitations required by the isolation requirements (see Isolation). In this case, the building would need two isolation zones, each no larger than 25,000 square feet, and each having its own time switch.

Example 4-14: Thermostat with Sensors

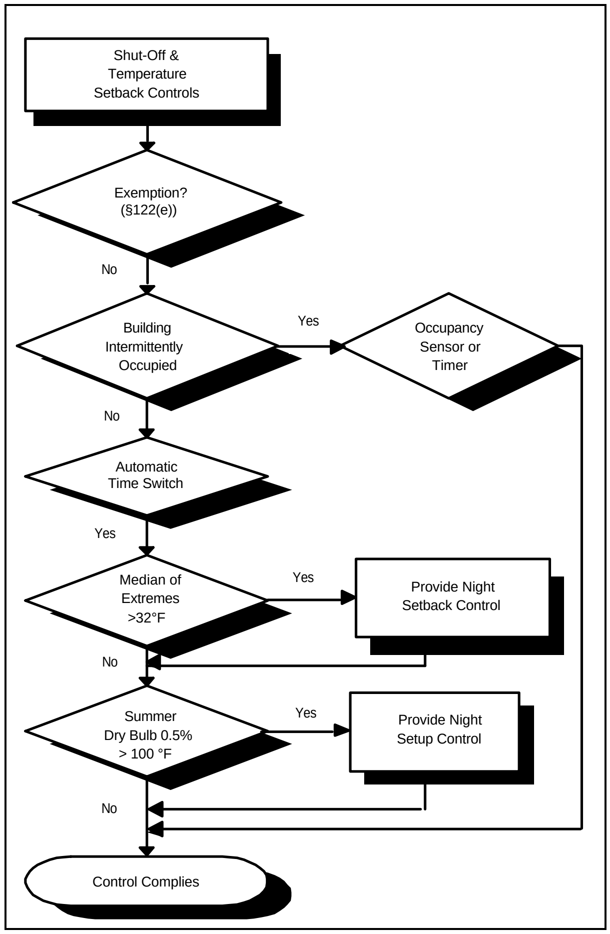
Question

Can a thermostat with setpoints determined by sensors (such as a bi-metal sensor encased in a bulb) be used to accomplish a night setback?

Answer

Yes. The thermostat must have two heating sensors, one each for the occupied and unoccupied temperatures. The controls must allow the setback sensor to override the system shutdown.

Figure 4-7: Shut-Off and Setback Controls Flowchart



These provisions are required by the *Standards* to reduce the likelihood that shut-off controls will be circumvented to cause equipment to operate continuously during unoccupied hours.

Automatic shut-off, setback and setup devices are not required where:

1. It can be demonstrated to the satisfaction of the enforcement agency that the system serves an area that must operate continuously (Section 122(e) Exception No. 1); or

2. It can be demonstrated to the satisfaction of the enforcement agency that shutdown, setback, and setup will not result in a decrease in overall building source energy use (Section 122(e) Exception No. 2); or

3. *Systems* have a full load demand less than 2 kW, or 6,828 Btu/hr, if they have a readily accessible manual shut-off switch (Section 122(e) Exception No. 3). Included is the energy consumed within all associated space-conditioning systems including compressors, as well as the energy consumed by any boilers or chillers that are part of the system.

4. Systems serve hotel/motel guest rooms, if they have a readily accessible manual shut-off switch Section 122(e) Exception No.4).

5. The mechanical system serves retail stores and associated malls, restaurants, grocery stores, churches, or theaters equipped with a 7 day programmable timer.

Example 4-15: Time Control for Fan Coils

Question

If a building has a system comprised of 30 fan coil units, each with a 300 watt fan, a 500,000 Btu/hr boiler, and a 30-ton chiller, can an automatic time switch be used to control only the boiler and chiller (fan coils operate continuously)?

Answer

No. The 2 kW criteria applies to the system as a whole, and is not applied to each component independently. While each fan coil only draws 300 watts, they are served by a boiler and chiller that draw much more. The consumption for the system is well in excess of 2 kW.

Assuming the units serve a total area of less than 25,000 square feet (see Isolation), one time switch may control the entire system.

Dampers (§122(f))

Outdoor air supply and exhaust equipment must incorporate dampers that automatically close when fans shut down. The dampers may either be motorized, or of the gravity type.

Damper control is not required where it can be demonstrated to the satisfaction of the enforcement agency that the space-conditioning system must operate continuously (Exception No. 1). Nor is damper control required on gravity ventilators or other non-electrical equipment, provided that readily accessible manual controls are incorporated (Exception No. 2).

Damper control is also not required at combustion air intakes and shaft vents, or where prohibited by other provisions of law (Exceptions No. 3 and 4). If the designer elects to install dampers or shaft vents to help control stack-induced infiltration, the damper should be motorized and controlled to open in a fire in accordance with applicable fire codes.

Isolation Area Devices (§122(g))

Large space-conditioning systems serving multiple zones may waste considerable quantities of energy by conditioning all zones when only a few zones are occupied. Typically, this occurs during evenings or weekends when only a few people are working. When the total area served by a system exceeds 25,000 square feet, the *Standards* require that the system be designed, installed and controlled with area isolation devices to minimize energy consumption during these times. The requirements are:

1. The building shall be divided into isolation areas, the area of each not exceeding 25,000 square feet. An isolation area may consist of one or more *zones*.

2. Each isolation area shall be provided with isolations devices such as valves or dampers, that allow the supply of heating or cooling to be setback or shut off independently of other isolation areas.

3. Each isolation area shall be controlled with an automatic time switch, occupancy sensor, or manual timer. The requirements for these shut-off devices are the same as described previously in Section 122(e)1. As discussed previously for occupancy sensors, a building purge must be incorporated into the control sequences for normally occupied spaces, so occupancy sensors and manual timers are best limited

to use in those areas that are intermittently occupied.

Any zones requiring continuous operation do not have to be included in an isolation area.

Example 4-16: Isolation Zones

Question   *How many isolation zones does a 55,000 sf building require?*   ***Answer***
At least three. Each isolation zone may not exceed 25,000 square feet.

Isolation of Zonal Systems

Small zonal type systems such as water loop heat pumps or fan coils may be grouped on automatic time switch devices, with control interlocks that start the central plant equipment whenever any isolation area is occupied. The isolation requirements apply to equipment supplying heating and cooling only; central ventilation systems serving zonal type systems do not require these devices.

Isolation of Central Air Systems

Central air handling stations may incorporate supply and return dampers on a floor-by-floor or other basis, provided the total area of each isolation zone does not exceed 25,000 square feet. Smoke/fire dampers required by other codes may be used for this purpose if approved by the fire authority having jurisdiction. The system does not require isolation on the return air side.

VAV boxes may be controlled to shut-off directly, eliminating the need for dampers in the supply.

Example 4-17: Isolation Zone Purge

Question   *Does each isolation zone require a ventilation purge?*   ***Answer***
Yes.

Isolation of Central Plants

The *Standards* do not require any isolation of central plant equipment. It is recommended that the number and type of boilers, chillers, pumps, and other central equipment be chosen so that the plant efficiency at part load is equal to or greater than the efficiency at full load. Since space-conditioning systems seldom operate at peak conditions, this approach will reduce energy consumption during times of normal occupancy, in addition to off-hours.

Interference with Fire and Life Safety

Isolation devices should not interfere with the function of any fire and life safety systems. For example, if an isolation damper is located in the same duct or opening as a smoke/fire damper controllable from the fire panel, the isolation damper should be interlocked to open in a fire situation so as not to interfere with the operation of the smoke/fire damper. The same is true for VAV boxes if they are used for isolation purposes.

I. Requirements for Pipe Insulation (§123)

Most piping conveying either mechanically heated or chilled fluids for space conditioning or service water heating must be insulated in accordance with Section 123. The required thickness of piping insulation depends on the temperature of the fluid passing through the pipe, the pipe diameter, the function of the pipe within the system, and the insulation's thermal conductivity. Table 4-3 (Table No. 1-G in the *Standards*) specifies the requirements in terms of inches of fiberglass or foam pipe insulation. In this table, runouts are defined as being less than two-inches in diameter, less than 12 feet long, and connected to fixtures or individual terminal units.

Piping that does not require insulation includes the following:

1. Factory installed piping within certified space-conditioning equipment.

2. Piping that conveys fluid with a design operating temperature range between 60°F and 105°F, such as cooling tower piping or piping in water loop heat pump systems.

3. Piping that serves process loads, gas piping, cold domestic water piping, condensate drains, roof drains, vents or waste piping.

> Note:
>
> Designers may specify exempt piping conveying cold fluids to be insulated in order to control condensation on the surface of the pipe. Examples may include cold domestic water piping, condensate drains and roof drains. In these cases, the insulation R-value is specified by the designer and is not subject to these regulations.

4. Where the heat gain or heat loss, to or from piping without insulation, will not increase building source energy use. For example, piping connecting fin-tube radiators within the same space would be exempt.

   This exception would not exempt piping in solar systems. Solar systems typically have backup devices that will operate more frequently if piping losses are not minimized.

Conductivities and thicknesses listed in Table 4-3 are typical for fiberglass and foam. When insulating materials are used that have conductivities different from those listed here for the applicable fluid range, such as calcium silicate, Equation 4-1 must be used to calculate the required insulation thickness.

When a pipe carries cold fluids, condensation of water vapor within the insulation material may impair the effectiveness of the insulation, particularly for applications in very humid environments or for fluid temperatures below 40°F. Examples include refrigerant suction piping and low-temperature thermal energy storage (TES) systems. In these cases, manufacturers should be consulted and consideration given to low permeability vapor barriers, or closed-cell foams.

Table 4-3: Pipe Insulation Thickness

Fluid Temperature Range	Conductivity Range (in Btu-inch per hour per sf. per degree F)	Insulation Mean Rating Temperature	Nominal Pipe Diameter (in inches) Runouts up to 2	1 and Less	1.25 - 2	2.50 - 4	5 - 6	8 and Larger
			Insulation Thickness Required (in inches)					
Space Heating Systems (Steam, Steam Condensate and Hot Water)								
Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Service Water Heating Systems (recirculating sections, all piping in electric trace tape systems, and the first 8 feet of piping from the storage tank for non-recirculating systems)								
Above 105	0.24-0.28	100	0.5	1.0	1.0	1.5	1.5	1.5
Space Cooling Systems (Chilled Water, Refrigerant, and Brine)								
40-60	0.23-0.27	75	0.5	0.5	0.5	1.0	1.0	1.0
Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

Equation 4-1: Insulation Thickness

$$T = PR[(1 + t/PR)^{K/k} - 1]$$

Where:

T = Minimum insulation thickness for material with conductivity K, inches.

PR = Pipe actual outside radius, inches.

t = Insulation thickness from Table 4-3, inches.

K = Conductivity of alternate material at the mean rating temperature indicated in Table 4-3 for the applicable fluid temperature range, in Btu-in/(hr-sf-°F).

k = The lower value of the conductivity range listed in Table 4-3 for the applicable fluid temperature, Btu-in/(hr-sf-°F).

Example 4-18: Pipe Insulation Thickness

Question

What is the required thickness for calcium silicate insulation on a 4 inch diameter pipe carrying a 300°F fluid?

Answer

From Table 4-3, the required insulation thickness is 2.5 inches for a 4 inch pipe in the range of 251-350°F. The mean conductivity at this temperature is listed as 0.29 (Btu-in) / (hr-sf-°F). From manufacturer's data, it is determined that the conductivity of calcium silicate at 300°F is 0.45 Btu-in/(hr-sf-°F). The required thickness is therefore:

$$T = PR[(1 + t/PR)^{K/k} - 1]$$

$$T = 4''[(1 + 2.5/4)^{0.45/0.29} - 1]$$

T = 4.3 inches

When insulation is not available in the exact thickness calculated, the installed thickness should be the next larger available size.

J. Requirements for Air Distribution System Ducts and Plenums (§124)

Poorly sealed or poorly insulated duct work can cause substantial losses of air volume and energy. The 1998 amendments include more detailed requirements for constructing ducts and plenums. All air distribution system ducts and plenums, including building cavities, mechanical closets, air handler boxes and support platforms used as ducts or plenums, are required to be installed, sealed, and insulated in accordance with the 1997 Uniform Mechanical Code (UMC) Sections 601, 603, 604 and Standard 6-3.

Installation and Insulation (§124(a))

Ducts or plenums conveying conditioned air must either be insulated to R-4.2 (or any higher level required by UMC Section 604), or be enclosed entirely in conditioned space. UMC insulation requirements are reproduced in Table 4-4. The following are also required:

- Mechanically fasten connections between metal ducts and the inner core of flexible ducts.
- Seal openings with mastic, tape, aerosol sealant or other duct closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B.
- When mastic or tape is used to seal openings greater than 1/4 inch, a combination of mastic and mesh or mastic and tape must be used.

Duct and Plenum Materials (§124(b))

Factory-Fabricated Duct Systems

Factory-fabricated duct systems must meet the following requirements:

- Duct and closure systems comply with UL 181, including collars, connections and splices, and must be UL labeled.
- Pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts comply with UL 181.
- Pressure-sensitive tapes and mastics used with flexible ducts comply with UL 181 or UL 181B.

Field-Fabricated Duct Systems

Field-fabricated duct systems must meet the following requirements:

- Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems comply with UL 181. Pressure-sensitive tapes, mastics, aerosol sealants or other closure systems must meet applicable requirements of UL 181, UL 181A or UL 181B.
- Mastic Sealants and Mesh.

  ‣ Sealants comply with UL 181, UL 181A, or UL 181B, and must be non-toxic and water resistant.

  ‣ Sealants for interior applications pass ASTM tests C 731(extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.

  ‣ Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.

  ‣ Sealants and meshes shall be rated for exterior use.
- Pressure-sensitive tapes comply with UL 181, UL 181A or UL 181B.
- Drawbands used with flexible duct shall:

- Be either stainless-steel worm-drive hose clamps or uv-resistant nylon duct ties.
- Have a minimum tensile strength rating of 150 pounds.
- Be tightened as recommended by the manufacturer with an adjustable tensioning tool.

• Aerosol-Sealant Closures.

  - Aerosol sealants meet applicable requirements of UL 181, 181A or 181B and must be applied according to manufacturer specifications.
  - Tapes or mastics used in combination with aerosol sealing must meet the requirements of this section.

Example 4-19: Duct Sealing

Question

What are the sealing requirements in a VAV system having a static pressure setpoint of 1.25” w.g. and a plenum return?

Answer

All duct work located within the return plenum must be sealed in accordance with the UMC Section 601,603,604. Pressure-sensitive tape, heat-seal tape and mastic may be used, if it meets the applicable requirement of UL 181, 181A, 181B, to seal joints and seams which are mechanically fastened per the UMC.

K. Service Water Systems (§113)

Efficiency and Controls (§113(a))

Any service water heating system or equipment may be installed only if the manufacturer has certified that the equipment meets or exceeds the efficiency requirements listed in Appendix B, Table B-9. The equipment must also have integral automatic temperature controls that allow the temperature to be adjusted from the lowest to the highest allowed temperature settings for the intended use as listed in Table 3, Chapter 45 of the 1995 *ASHRAE Handbook, HVAC Applications Volume*.

Service water heaters installed in residential occupancies need not meet the control requirement.

Table 4-4: Duct Insulation Requirements

DUCT LOCATION [1]	INSULATION R-VALUE MECHANICALLY COOLED	HEATING ZONE	INSULATION R-VALUE HEATING ONLY
On roof on exterior building	6.3	< 4,500 DD	2.1
		< 8,000 DD	4.2
Attics, garages, and crawl spaces	2.1	< 4,500 DD	2.1
		< 8,000 DD	4.2
In walls [2] and within floor to ceiling spaces[2]	2.1	< 4,500 DD	2.1
		< 8,000 DD	4.2
Within the conditioned space or in basements; return ducts in air plenums	None Required		None Required
Cement slab or within ground	None Required		None Required

[1] Vapor barriers shall be installed on supply ducts in spaces vented to the outside in geographic areas where the average July, August and September mean dew point temperature exceeds 60 degrees Fahrenheit.

[2] Insulation may be omitted on that portion of a duct which is located within a wall or a floor to ceiling space where:

a. Both sides of the space are exposed to conditioned air.
b. The space is not ventilated.
c. The space is not used as a return plenum.
d. The space is not exposed to unconditioned air.

Ceilings which form plenums need not be insulated.

NOTE: Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

Source: Uniform Mechanical Code §604

Multiple Temperature Usage (§113(b)1)

On systems that have a total capacity greater than 167,000 Btu/hr, outlets requiring higher than service water temperatures as listed in the 1995 *ASHRAE Handbook, HVAC Applications Volume* shall have separate remote heaters, heat exchangers, or boosters to supply the outlet with the higher temperature. This requires the primary water heating system to supply water at the lowest temperature required by any of the demands served for service water heating. All other demands requiring higher temperatures should be served by separate systems, or by boosters that raise the temperature of the primary supply.

Circulating Systems (§113(b)2)

Circulating service water systems must include a control capable of automatically turning off the circulating pump when hot water is not required. Such controls include automatic time switches, interlocks with HVAC time switches, occupancy sensors, and other controls that accomplish the intended purpose. Since residential occupancies have different supply requirements they do not have to meet the requirements of Section 113(b)2.

Public Lavatories (§113(b)3)

Lavatories in public restrooms must have controls that limit the water supply temperature to 110°F. Where a service water heater supplies only restrooms, the heater thermostat may be set to no greater than 110°F to satisfy this requirement; otherwise controls such as automatic mixing valves must be installed.

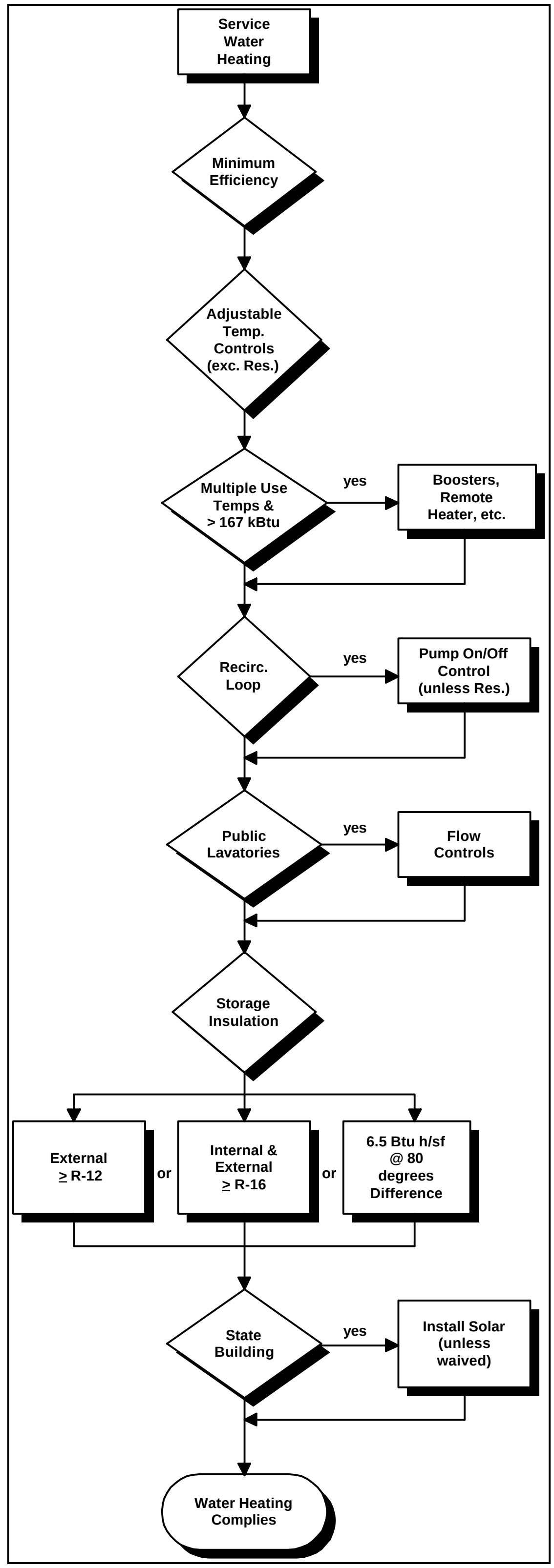
Storage Tank Insulation (§113(b)4)

Unfired water heater storage tanks and backup tanks for solar water heating systems must have:

1. **External insulation** with an installed R-value of at least R-12; or

2. **Internal and external insulation** with a combined R-value of at least R-16; or

Figure 4-8: Service Water Heating Flowchart



3. The **heat loss** of the tank based on an 80 degree F water-air temperature difference shall be less than 6.5 Btu per hour per square foot. This corresponds to an effective resistance of R-12.3.

Service Water Heaters in State Buildings (§113(b)5)

Any new building constructed by the State shall derive its service water heating from a system that provides at least 60 percent of the energy needed from site solar energy or recovered energy. This requirement may be waived for buildings where the State Architect determines that such systems are economically or physically infeasible.

L. Pool and Spa Heating Systems (§114)

Pool and spa heating systems must be certified by the manufacturer and listed by the Energy Commission as having:

1. An **efficiency** of at least 78 percent when tested according to ANSI Standard Z21.56-1994; and

2. An **on-off switch** mounted on the outside of the heater in a readily accessible location that allows the heater to be shut-off without adjusting the thermostat setting; and

3. A permanent, easily readable, and weatherproof plate or card that gives **instructions** for the energy efficient operation of the pool or spa, and for the proper care of the pool or spa water when a cover is used; and

4. No **electric resistance heating**. The only exceptions are:

    a. *Packaged listed units* with fully insulated enclosures and tight fitting covers that are insulated to at least R-6. Package listed units are defined in the *National Electric Code* and are typically sold as self-contained, UL Listed spas; or

    b. Pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy.

5. **No pilot light.**

Pool and spa equipment must be installed with all of the following:

1. **Solar heater connection** - At least 36 inches of pipe between the filter and the heater must be provided to allow for the future addition of solar heating equipment.

2. A **cover** must be provided for outdoor pools and outdoor spas, unless at least 60 percent of the annual heating energy is provided by site solar energy or recovered energy.

3. **Directional inlets** must be provided for all pools that adequately mix the pool water.

4. A **time switch** must be provided for pools to control the operation of the circulation pump, to allow the pump to be set to run in the off-peak demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

    A time switch is not required where applicable public health standards require on-peak operation.

4.2.2 Prescriptive Approach

This section presents requirements that must be incorporated into the system design if the prescriptive path of compliance is used. Unlike mandatory requirements, however, these requirements may be traded off against other measures if the designer elects to use the performance path.

A. Sizing and Equipment Selection (§144(a))

The energy efficiency of many types of equipment can be lower at part load than at full load. The *Standards*, therefore, require that mechanical heating and cooling equipment (including electric heaters and boilers) be the smallest size available, within the available options of the desired equipment line, that meets the design heating and cooling loads of the building or spaces being served.

When equipment is offered in size increments, such that one size is too small and the next is too large, the larger size may be selected.

Packaged HVAC equipment may serve a space having substantially different heating and cooling loads. The unit size should be selected on the larger of the loads, based on either capacity or airflow. The capacity for the other load should be selected as required to meet the load, or if very small, should be the smallest capacity available in the selected unit. For example, packaged air-conditioning units with gas heat are usually sized on the basis of cooling loads. The furnace is sized on the basis of airflow, and is almost always larger than the design heating load.

Equipment may be oversized provided one or more of the following conditions are met:

1. It can be demonstrated to the satisfaction of the enforcing agency that oversizing will not increase building source energy use; or

2. Oversizing is the result of standby equipment that will operate only when the primary equipment is not operating. Controls must be provided that prevent the standby equipment from operating simultaneously with the primary equipment; or

3. Multiple units of the same equipment type are used, each having a capacity less than the design load, but in combination having a capacity greater than the design load. Controls must be provided to sequence or otherwise optimally control the operation of each unit based on load.

B. Load Calculations (§144(b))

For the purposes of sizing HVAC equipment, the designer shall use all of the following criteria for load calculations:

1. The heating and cooling system **design loads** must be calculated in accordance with the procedures described in the *ASHRAE Handbook, 1993, Fundamentals Volume*. Other load calculation methods, e.g. ACCA, SMACNA, *etc.* are acceptable provided that the method is ASHRAE-based. When submitting load calculations of this type, the designer must accompany the load calculations with a written affidavit certifying that the method used is ASHRAE-based. If the designer is unclear as to whether or not the calculation method is ASHRAE-based, the vendor or organization providing the calculation method should be contacted to verify that the method is derived from ASHRAE.

Example 4-20: Equipment Sizing

Question

Do the sizing requirements restrict the size of duct work, coils, filter banks, etc. in a built-up system?

Answer

The intent of the Standards is to limit the size of equipment which, if oversized, will consume more energy on an annual basis. Coils with larger face areas will usually have lower pressure drops than otherwise, and may also allow the chilled water temperature to be higher, both of which may result in a decrease in energy usage. Larger filter banks will also usually save energy. Larger duct work will have lower static pressure losses which may save energy, depending on the duct's location, length, and degree of insulation. An oversized airfoil fan with inlet vanes will not usually save energy, as the part load characteristics of this device are poor. The same fan with a variable frequency drive may save energy. Controls are also an important part of any system design.

The relationship between various energy consuming components may be complex, and is left to the designer's professional judgment. Note however, that when components are oversized, it must be demonstrated to the satisfaction of the enforcement agency that energy usage will not increase.

2. **Indoor design conditions** of temperature and relative humidity for general comfort applications are not explicitly defined. Designers are allowed to use any temperature conditions within the "comfort envelope" defined by ANSI/ASHRAE 55-1992 or Chapter 8 of the *ASHRAE Handbook, 1993, Fundamentals Volume*. Winter humidification or summer dehumidification is not required.

3. **Outdoor design conditions** shall be selected from ASHRAE Publication SPCDX: Climatic Data for Region X, Arizona, California, Hawaii, and Nevada, 1982 for the following design conditions:

   Heating design temperatures shall be no lower than the temperature listed in the Winter Median of Extremes column.

   Cooling design dry bulb temperatures shall be no greater than the temperature listed in the Summer Design Dry Bulb 0.5% column. The design wet bulb temperature shall be no greater than the temperature listed in the Summer Design Wet Bulb 0.5% column.

4. **Outdoor Air Ventilation** loads must be calculated using the ventilation rates required in Section 121. At minimum, the ventilation rate will be 15 cfm/person or 0.15 cfm/sf, whichever is greater.

5. **Envelope** heating and cooling loads must be calculated using envelope characteristics including square footage, thermal conductance, solar heat gain coefficient and air leakage, consistent with the proposed design.

5. **Lighting** loads shall be based on actual design lighting levels or power densities consistent with Section 146.

7. **People** sensible and latent gains must be based on the expected occupant density of the building and occupant activities. If ventilation requirements are based on a cfm/person basis, then people loads must be based on the same number of people as ventilation. Sensible and latent gains must be selected for the expected activities as listed in *ASHRAE Handbook, 1993, Fundamentals Volume*, Chapter 26, Table 3.

8. **Loads** caused by a process shall be based on actual information (not speculative) on the intended use of the building.

9. **Miscellaneous equipment loads** include such things as duct losses, process loads and infiltration and shall be calculated using design data compiled from one or more of the following sources:

   a. **Actual information** based on the intended use of the building; or

   b. Published data from manufacturer's technical publications and from technical societies, such as the ASHRAE Handbook, 1995 HVAC Applications Volume; or

   c. Other data based on the designer's experience of expected loads and occupancy patterns.

10. **Internal heat gains** may be ignored for heating load calculations.

11. A **safety factor** of up to 10 percent may be applied to design loads to account for unexpected loads or changes in space usage.

12. **Other loads** such as warm-up or cool-down shall be calculated using one of the following methods:

    a. A method using principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time; or

    b. The steady state design loads may be increased by no more than 30 percent for heating and 10 percent for cooling.

The steady state load may include a safety factor of up to 10 percent as discussed above in Item 11.

The combination of safety factor and other loads allows design cooling loads to be increased by up to 21 percent (1.10 safety x 1.10 other), and heating loads by up to 43 percent (1.10 safety x 1.30 other).

C. Fan Power Consumption (§144(c))

Maximum fan power is regulated in individual fan systems where the total power index of the supply, return and exhaust fans within the *fan system* exceed 25 horsepower at design conditions (see Section 4.1.2 for definitions). A system consists of only the components that must function together to deliver air to a given area; fans that can operate independently of each other comprise separate systems. Included are all fans associated with moving air from a given space-conditioning *system* to the conditioned spaces and back to the source, or to exhaust it to the outdoors.

The 25 horsepower total criteria apply to:

1. All **supply and return fans** within the space-conditioning system that operate at peak load conditions.

2. All **exhaust fans at the system level** that operate at peak load conditions. Exhaust fans associated with economizers are not counted provided they do not operate at peak conditions.

3. **Fan-powered VAV boxes**, if these fans run during the cooling peak. This is always the case for fans in series type boxes. Fans in parallel boxes may be ignored if they are controlled to operate only when zone heating is required, and are normally off during the cooling peak.

4. **Elevator equipment room exhausts**, or other exhausts that draw air from a conditioned space, through an otherwise unconditioned space, to the outdoors.

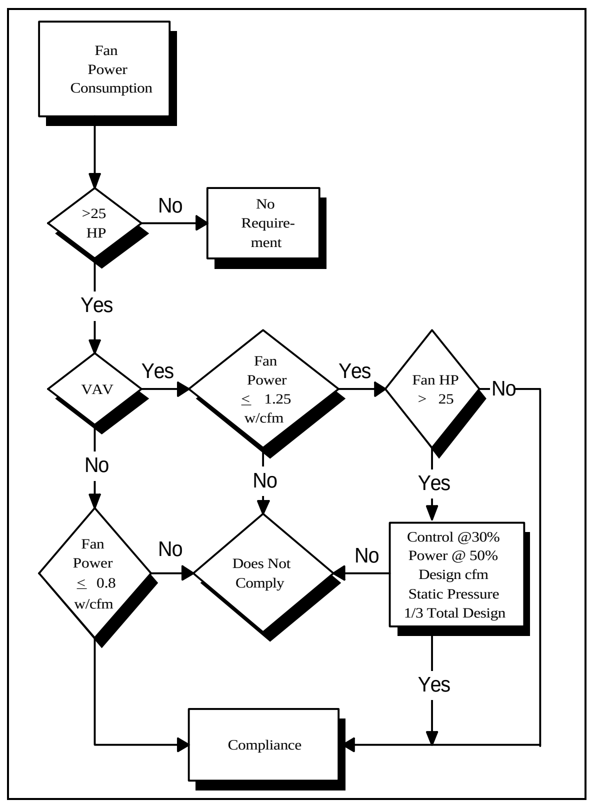
5. **Computer** room units.

   The criteria are applied individually to each space-conditioning system. In buildings having multiple space-conditioning systems, the criteria applies only to the systems having fans whose total demand exceeds 25 horsepower.

   Not included are fans not directly associated with moving conditioned air to or from the space-conditioning system, or fans associated with a process within the building.

For the purposes of the 25 horsepower criteria, horsepower is the brake horsepower as listed by the manufacturer for the design conditions, plus any losses associated with the drive, including belt losses or variable frequency drive losses. If the brake horsepower is not known, then the nameplate horsepower should be used.

Figure 4-9: Fan Power Consumption Flowchart



Example 4-21: 25 HP Limit

Question
If a building has five zones with 15,000 cfm air handlers that are served by a common central plant, and each air handler has a 15 HP supply fan, does the 25 HP limit apply?
Answer
No. Each air handler, while served by a common central plant, is considered a separate space-conditioning system. Since the demand of each air handler is only 15 HP, the 25 HP criteria does not apply.

If drive losses are not known, the designer may assume that direct drive efficiencies are 1.0, and belt drives are 0.97. Variable speed drive efficiency should be taken from the manufacturer's literature; if it includes a belt drive, it should be multiplied by 0.97.

Total fan horsepower need not include the additional power demand caused solely by air treatment or filtering systems with final pressure drops of more than 1 inch water gauge (w.g.). It is assumed that conventional systems may have filter pressure drops as high as 1 inch w.g.; therefore only the horsepower associated with the portion of the pressure drop exceeding 1 inch, or fan system power caused solely by process loads, may be excluded.

For buildings whose systems exceed the 25 horsepower criteria, the total space-conditioning system power requirements are:

Example 4-22: Filtration

Question

The space-conditioning system in a laboratory has a 30 percent filter with a design pressure drop at change out of 0.5 inch w.g., and an 80 percent filter with a design pressure drop of 1.2 inch w.g. The design total static pressure of the fan is 5.0 inchw.g. What percentage of the power may be excluded from the Watts/cfm calculation?

Answer

The total filter drop at change out (final pressure drop) is 0.5 inch + 1.2 inch = 1.7 inch w.g. The amount that may be excluded is 1.7 inch-1.0 inch = 0.7 inch w.g. The percentage of the horsepower that may be excluded is

0.7"/5.0" = 14%

If the supply fan requires 45 brake horsepower, the adjusted horsepower of the supply fan in the Watts/cfm calculation is

45 BHP x (1 - 14%) = 38.7 BHP

The horsepower of any associated return or exhaust fan is not adjusted by this factor, as the filters have no impact on these fans.

1. ***Constant volume*** space-conditioning systems shall not exceed 0.8 watts per cfm of supply air.

2. ***Variable Air Volume (VAV)*** systems shall not exceed 1.25 Watts per cfm of supply air at design conditions.

   In addition, individual VAV fans with motors over 25 horsepower shall meet three requirements: 1) a mechanical or electrical variable speed drive fan motor; 2) vane axial fan with variable pitch blades; and 3) include controls that limit the fan motor demand to no more than 30 percent of design wattage at 50 percent design air volume.

   Actual fan part load performance, available from the fan manufacturer, should be used to test for compliance with item 3) above. Figure 4-10 shows typical performance curves for different types of fans. As can be seen, both airfoil fans and backward inclined fans using either discharge dampers or inlet vanes consume more than 30 percent power at 50 percent flow when static pressure set point is one-third of total design static pressure using certified manufacturer's test data. These fans will not normally comply with these requirements unless a variable speed drive is used.

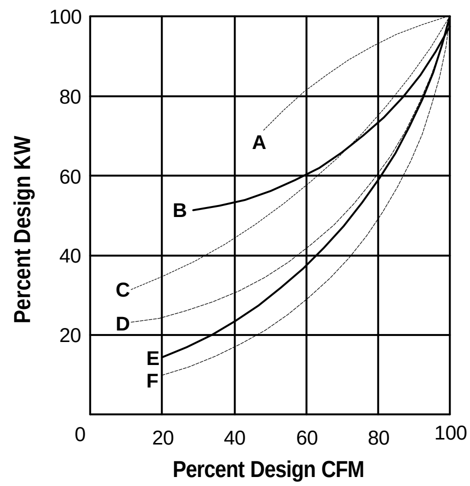
The total system power demand is based on brake horsepower at design static and cfm, and includes drive losses and motor efficiency. If the motor efficiency is not known, values from Appendix B, Table B-8A & 8B, may be assumed.

The power demand is calculated on a system by system basis, and the maximum limit applies to each system individually. In other words, the power demands of separate systems cannot be averaged.

Example 4-23: VAV Bypass System

Question
What is the maximum allowed power consumption for the fans in a VAV bypass system?
Answer
A VAV bypass, while variable volume at the zone level, is constant volume at the fan level. If the total fan power demand of this system exceeds 25 HP, then the fan power may not exceed 0.8 Watts/cfm.

Figure 4-10: VAV Fan Performance Curve



A. Air foil or backward inclined centrifugal fan with discharge dampers
B. Air foil centrifugal fan with inlet vanes
C. Forward curved centrifugal fan with discharge dampers or riding curve
D. Forward curved centrifugal fan with inlet vanes
E. Vane-axial fan with variable pitch blades
F. Any fan with variable speed drive (mechanical drives will be slightly less efficient)

Example 4-24: Calculation of Fan Power

Question
What is the power consumption of a 20,000 cfm VAV system having an 18 BHP supply fan, a 5 BHP return fan, a 3 BHP economizer relief fan, a 2 HP outside air ventilation fan and a 1 HP toilet exhaust fan? Note that the exhaust and outside air ventilation fans are direct drive and listed in HP not BHP. The supply and return fans are controlled with variable frequency drives having an efficiency of 96 percent.
Answer
The economizer fan is excluded provided it does not run at the time of the cooling peak.

Power consumption is then based on the supply, return, outdoor and toilet exhaust fans. The ventilation fan is direct drive so its efficiency is 1.0. The supply and return fans have default drive efficiencies of 0.97. From Table B-8A & 8B, the assumed efficiencies of the motors are 88 percent and 85 percent for a 25 and 7.5 HP motor respectively. Fan power demand in units of horsepower must first be calculated to determine whether the requirements apply:

a. 18 BHP / (0.97 x 0.88 x 0.96) = 22.0 HP

b. 5 BHP / (0.97 x 0.85 x 0.96) = 6.3 HP

Total power consumption, adjusted for efficiencies, is calculated as:

22.0 HP + 6.3 HP + 2 HP + 1 HP = 31.3 HP

Since this is larger than 25 HP, the limitations apply. Watts per cfm is calculated as:

31.3 HP x 746 Watts/cfm/20,000 cfm = 1.17 Watts/cfm

The system complies because power consumption is below 1.25 Watts per cfm. Note that, while this system has variable frequency drives, they are not required by the Standards since each fan is less than 25 HP.

D. Space Conditioning Zone Controls (§144(d))

Each space-conditioning zone shall have controls that prevent:

1. **Reheating** of air that has been previously cooled by mechanical cooling equipment or an economizer.
2. **Recooling** of air that has been previously heated. This does not apply to air returned from heated spaces.
3. **Simultaneous heating and cooling** in the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.

These requirements do not apply to zones having:

1. **VAV controls**, as discussed in Section E. below;
2. **Special pressurization relationships** or cross contamination control needs. Laboratories are an example of spaces that might fall in this category.
3. **Site-recovered or site-solar** energy providing at least 75 percent of the energy for reheating, or providing warm air in mixing systems.
4. **Specific humidity requirements** to satisfy process needs.
5. **300 cfm or less** peak supply air quantity. This exception allows reheating or recooling to be used in small zones served by constant volume systems.

Example 4-25: Minimum VAV CFM

Question

What is the required minimum cubic feet per minute (cfm) for a 1000 square foot office having a design supply of 1100 cfm and eight people?

Answer

Based on reheat requirements, the minimum cfm should not exceed the larger of:

a. 1000 sf x 0.4 cfm/sf = 400 cfm; or

b. 1100 cfm x 30% = 330 cfm; or

c. 300 cfm

Based on reheat, airflow must be reduced to no more than 400 cfm.

Outdoor ventilation requirements are the larger of:

a. 1000 sf x 0.15 cfm/sf = 150 cfm; or

b. 8 people x 15 cfm/person = 120 cfm

Based on ventilation requirements, the airflow must be at least 150 cfm. The minimum ventilation rate must then be in the range below the reheat requirement and above the ventilation requirement, or 150 – 400 cfm.

If, instead, the space were a conference room holding 35 people, then the design outdoor ventilation rate would be 35 x 15 = 525 cfm. Since this is above the reheat requirement of 400 cfm, the minimum cfm must be 525 cfm, unless transfer air is taken from other spaces

E. VAV Zone Controls (§144(d) Exception No. 1

Prior to reheating, recooling or mixing air, the controls in VAV zones must be set to reduce the air supply to a minimum. The minimum volume shall be no greater than the largest of:

1. 30 percent of the peak supply volume; or
2. 0.4 cfm per square foot of conditioned floor area of the zone; or
3. 300 cfm.

Note however, that Section 121(c) requires that the minimum rate of outdoor ventilation air calculated in Section 121(b)2 be supplied to each space at all times when the space is usually occupied. The allowable minimum airflow for a VAV box then usually falls in a range limited by the ventilation requirements at the lower end, and the reheat requirements at the upper end. In some cases, however, the required ventilation rate may be larger than the rate required for reheat. In this case, the required rate for reheat is the ventilation rate unless other provisions are made to supply ventilation air.

F. Economizers (§144(e))

An economizer must be fully integrated and must be provided for each individual cooling space-conditioning system that has a design supply capacity over 2,500 cfm and a total cooling capacity over 75,000 Btu/hr. The economizer may be either:

1. An ***air economizer*** capable of modulating outside air and return air dampers to supply 100 percent of the design supply air quantity as outside air. (For prescriptive compliance, samples of integrated economizers that meet this requirement are: fixed drybulb, differential drybulb, fixed enthalpy, or differential enthalpy); or

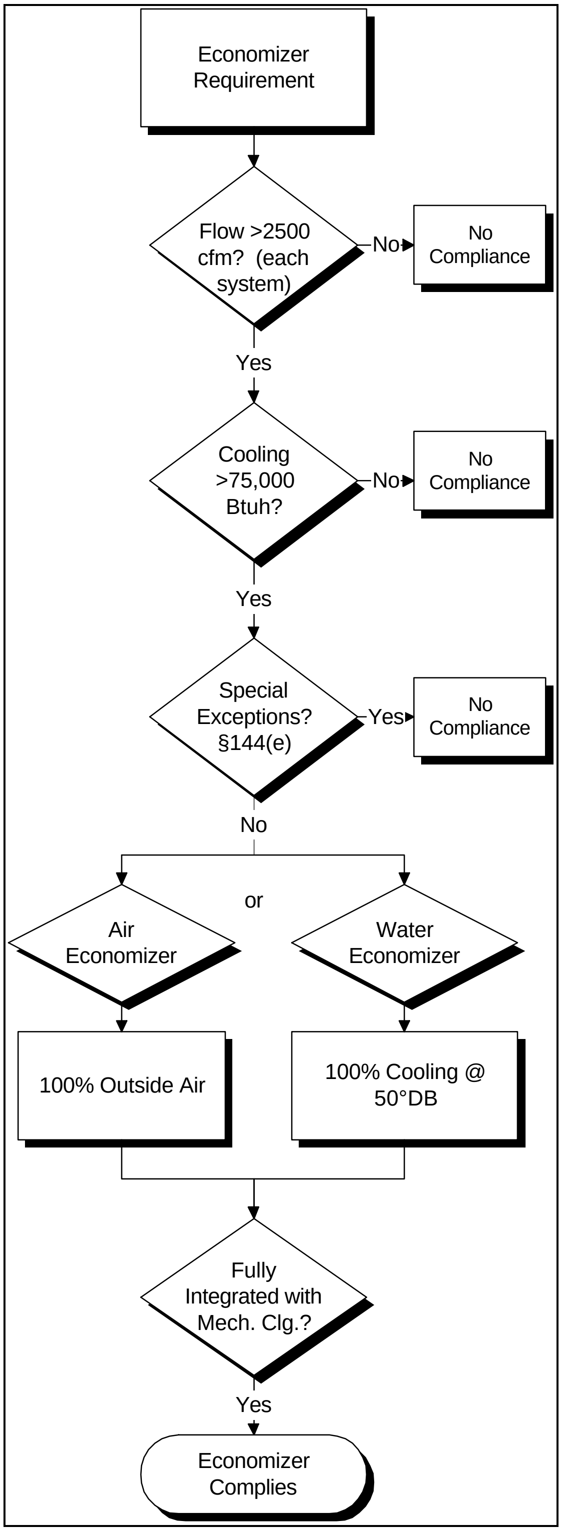
2. A ***water economizer*** capable of providing 100 percent of the expected system cooling load at outside air Figure temperatures of 50°F dry-bulb and 45°F wet-bulb and below. Economizers are not required where:

Economizers are not required where:

1. **Outside air filtration and treatment** for the reduction and treatment of unusual outdoor contaminants make compliance infeasible. This must be demonstrated to the satisfaction of the enforcement agency.

2. **Increased overall building energy use** results. This may occur where economizers adversely impact other systems, such as humidification, dehumidification or supermarket refrigeration systems.

Figure 4-11: Economizer Flowchart



3. Systems serving **high-rise residential living quarters** and **hotel/motel guest rooms**. Note that these buildings typically have systems smaller than 2,500 cfm, and also have provisions for natural ventilation.

4. If **cooling capacity** is less than or equal to 75,000 Btu/hr, or **supply airflow** is less than or equal to 2,500 cfm.

If an economizer is required, it must be designed and equipped with controls that do not increase the building heating energy use during normal operation. For example, when simultaneous cooling and zone reheat is required in a VAV system, the use of the economizer must not cause the supply air to be colder than it would be if the mechanical cooling were operating. The exception is when at least 75 percent of the annual heating is provided by site-recovered or site-solar energy (Section 144(e)2.A).

The economizer controls must also be fully *integrated* into the cooling system controls so that the economizer can provide partial cooling even when mechanical cooling is required to meet the remainder of the load Section 144(e)2.B).

The requirement that economizers be designed for concurrent operation is not met by some popular water economizer systems, such as those which use the chilled water system to convey evaporative-cooled condenser water for "free" cooling. Such systems can provide 100 percent of the cooling load, but when the point is reached where condenser water temperatures cannot be sufficiently cooled by evaporation, the system controls throw the entire load to the mechanical chillers. Because this design cannot allow simultaneous economizer and refrigeration system operation, it does not meet the requirements of this section.

Air economizers, water economizers and integrated controls are discussed in more detail in the Design Concepts section at the beginning of this Chapter.

G. Supply-Air Temperature Reset Control (§144(f))

Mechanical space-conditioning systems supplying heated or cooled air to multiple zones must include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls must be capable of resetting the supply-air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

For example, if the design supply temperature is 55°F and the design room temperature is 75°F, then the difference is 20°F, and 25 percent is 5°F. Therefore, the controls must be capable of resetting the supply temperature from 55°F to 60°F.

Air distribution zones that are likely to have constant loads, such as interior zones, shall have air flow rates designed to meet the load at the fully reset temperature. Otherwise, these zones may prevent the controls from fully resetting the temperature, or will unnecessarily limit the hours when the reset can be used.

Supply air reset is usually required for VAV reheat systems. It is also required for constant volume systems with reheat justified on the basis of special zone pressurization relationships or cross-contamination control needs.

Supply-air temperature reset is not required when:

1. The zone(s) must have specific humidity levels required to meet process needs; or

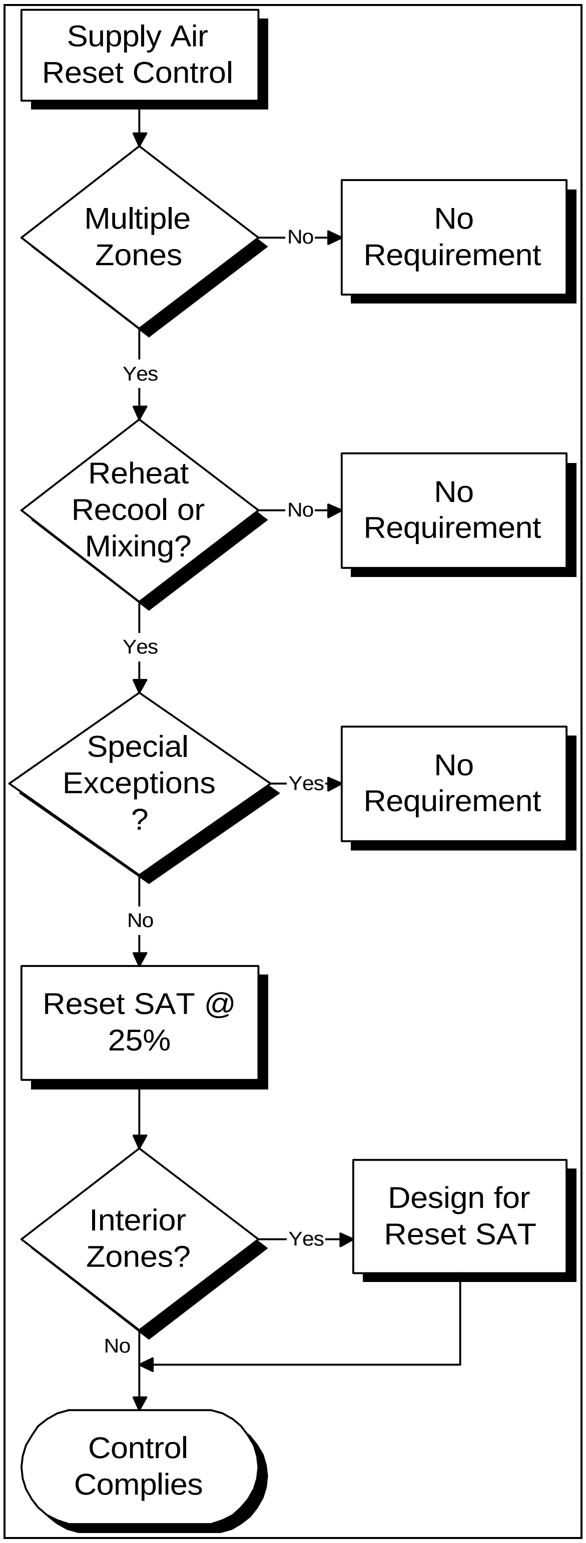
2. Where it can be demonstrated to the satisfaction of the enforcement agency that supply air reset would increase overall building energy use; or

3. The space-conditioning zone has controls that prevent reheating and recooling and simultaneously provide heating and cooling to the same zone; or

4. 75 percent of the energy for reheating is from *site-recovered* or *site solar* energy source; or

5. The zone has a peak supply air quantity of 300 cfm or less.

Figure 4-12: Supply Air Reset Controls Flowchart



H. *Electric-Resistance Heating (§144(g))*

The *Standards* strongly discourage the use of electric-resistance space heat. Electric-resistance space heat is not allowed in the prescriptive approach except where:

1. **Site-recovered** or **site-solar** energy provides at least 60 percent of the annual heating energy requirements; or

2. A **heat pump** is supplemented by an electric-resistance heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load at the design outdoor temperature, determined in accordance with these *Standards*; or

3. The **total capacity** of all electric-resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating equipment serving the entire building; or

4. The total capacity of all electric-resistance heating systems serving the building, excluding those that supplement a heat pump, is **no more than 3 kW**; or

5. An electric-resistance heating system serves an entire building that:

   a. Is not a high-rise residential or hotel/motel building; and

   b. Has a conditioned floor area no greater than 5,000 square feet; and

   c. Has no mechanical cooling; and

   d. Is in an area where natural gas is not currently available and an extension of a natural gas system is impractical, as determined by the natural gas utility.

6. In alterations where the existing mechanical systems use electric reheat (when adding variable air volume boxes) added capacity cannot exceed 20 percent of the existing installed electric capacity, under any one permit application.

7. In an addition where the existing variable air volume system with electric reheat is being expanded the added capacity cannot exceed 50 percent of the existing installed electric reheat capacity under any one permit.

The *Standards* in effect allow a small amount of electric-resistance heat to be used for local space heating or reheating (provided reheat is in accordance with these regulations).

Example 4-26: Heat Pump Sizing

Question

If a heat pump is used to condition a building having a design heating load of 100,000 Btu/hr at 35°F, what are the sizing requirements for the compressor and heating coils?

Answer

The compressor must be sized to provide at least 75 percent of the heating load at the design heating conditions, or 75,000 Btu/hr at 35°F. The Standards do not address the size of the resistance heating coils. Normally, they will be sized based on heating requirements during defrost.

I. Service Water Heating (§145)

A service water-heating system is considered to comply with the prescriptive requirements when all mandatory requirements are met. The *Standards* for low-rise residential buildings have been adopted for service water-heating systems in high-rise residential buildings (see Appendix H).

4.2.3 Performance Approach

Under the performance approach, the energy use of the building is modeled using a computer program approved by the Energy Commission. This section presents some basic details on the modeling of building mechanical systems. *Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific Instructions on the operation of the program*. All computer programs, however, are required to have the same basic modeling capabilities.

The details of how to model the mechanical systems and components are included in Section 6.1. Specific application scenarios are contained in Section 6.1.4.

A. Compliance With a Computer Method

Each approved computer method automatically generates an *energy budget* by calculating the annual energy use of the standard design, a version of the proposed building incorporating all the prescriptive features.

A building complies with the *Standard* if the predicted source *energy use* of the proposed design is the same or less that the annual *energy budget* of the standard design. The energy budget includes a space-conditioning budget, lighting budget and water-heating budget.

Source energy use defines the energy use of a building by converting the calculated energy consumption into *source energy.* A table of *source energy multipliers* is found in Section 102*.* Source energy multipliers adjust the calculated energy consumption of a building to account for the energy content of different fuels and inefficiencies in generating and distributing electricity.

The budget for space conditioning of the proposed building design varies according to the following specific characteristics:

- Orientation
- Conditioned floor area
- Conditioned volume
- Gross exterior surface area
- Space-conditioning system type

- Occupancy type
- Climate zone

Assumptions used by the computer methods in generating the energy budget are explained in the *Alternative Calculation Methods Approval Manual* and are based on features required for prescriptive compliance.

B. Modeling Mechanical System Components

All alternative computer programs have the capability to model various types of HVAC systems. In central systems, these modeling features affect the system loads seen by the plant. This is done by calculating the interactions between envelope, mechanical and electrical systems in the building and summarizing the energy required by the mechanical system to maintain space conditions.

For a complete description of how to model mechanical system components, refer to the compliance supplement for the approved computer program being used to demonstrate compliance.

4.2.4 Alterations/Additions

When heating, cooling or service water heating are provided for an alteration or addition by expanding an existing system, that existing system need not comply with mandatory measures or compliance requirements. However, any altered component must meet all applicable mandatory measures.

When existing heating, cooling, or service water heating systems or components are moved within a building, the existing systems or components need not comply with mandatory measures nor with the prescriptive or performance compliance requirements.

4.2.5 Application to Major System Types

This section summarizes the Mandatory, Prescriptive, and Performance Measures as they apply to the major mechanical system designs as used in California. The systems presented are:

- Packaged air conditioner with gas furnace or heat pump
- Packaged VAV reheat
- Built-up VAV reheat
- Built-up single-fan dual duct VAV
- Built-up or packaged dual-fan dual-duct VAV
- Packaged terminal air conditioner with gas furnace or heat pump
- Four-pipe fan-coil system with central plant
- Hydronic heat pump with central plant

For each of these systems, the mandatory, prescriptive and performance measures are described. Limitations imposed by the *Standards*, if any, are discussed together with mitigating measures that can be taken.

Although there are more variations and combinations of systems than are covered here, this section can be used as a guide for other systems. Where there are ambiguities, the designer should refer directly to the Sections describing the Mandatory and Prescriptive requirements.

To avoid excessive redundancy, this section contains the requirements that normally apply to systems. There are various exceptions to these requirements that are not included here; the designer should refer to the sections detailing the mandatory, prescriptive and performance requirements for these exceptions.

In the following, mandatory requirements are designated by **[M]**, prescriptive by **[P]**, and performance by **[Pf]**.

A. *Packaged Air Conditioner with Gas Furnace or Heat Pump*

A packaged air conditioner with gas furnace is a self-contained system that uses a gas furnace to heat the supply air, and a direct expansion coil and compressor to cool the supply air. The package also includes a supply fan, condenser fan(s) and possibly return or exhaust fans. The compressor and outside air heat exchanger may be either integral to the unit, or remote.

Heating may alternatively be provided with a heat pump. In this case, controls and changeover valves are incorporated so that the compressor and heat exchangers can alternately provide heating or cooling. This system is commonly called a packaged heat pump.

The system is most commonly used in a single zone configuration, but subzone VAV configurations with or without reheat are also used. Where VAV zoning exists, VAV requirements also apply.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing** must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. Any equipment listed in Appendix B, Table B-9, shall comply with the **listed efficiencies** [M].

3. **Fan power consumption** must be no more than 0.8 Watts/cfm of supply air for constant volume systems (Section 4.2.2C [P]. The limit applies to the sum of the power of all supply, return, and exhaust fans in the space-conditioning system that operate during the peak design period, including toilet exhaust fans. This requirement does not apply to any fans that do not operate at peak, such as economizer exhaust fans. The limit does not apply to any space-conditioning system having fans totaling less than 25 HP.

4. **Ventilation** shall be in accordance with Section 4.2.1D - G [M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

5. A fully integrated **economizer** with controls must be provided for each system delivering over 2,500 cfm supply air and 75,000 Btu/hr cooling (Section 4.2.2F) [P]. The designer should refer to Section 4.2.2F for the exceptions.

6. **Electric-resistance heating** for reheat, etc. is prohibited in most circumstances (Section 4.2.2H) [P].

   When a heat pump is specified with supplementary resistance heaters, the heat pump capacity using only the compressor must be at least 75 percent of the design heating load at design conditions per Section 4.2.2H [P].

   The designer should refer to Section 4.2.2H for the exceptions.

7. **Zone Controls** shall be in accordance with Section 4.2.1H [M] and Section 4.2.2D and E [P].

   For single zone systems, a **thermostat** must be provided to control heating and cooling to each zone [M]. The heating setpoint must be adjustable down to 55°F or lower, and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints, or the thermostat must be manually switched between heating and cooling.

   Ventilation air must be provided at least 55 out of every 60 minutes (Section 4.2.1G) [M]. When outdoor air ventilation is provided mechanically, the **Auto/On** fan switch, if any, should be set to On.

For constant volume systems with subzones, the system must be designed and provided with controls to prevent **reheating** of cooled or economizer air [P]. Variable volume systems have different requirements described in Section 4.2.2E.

8. **System controls** shall be in accordance with Section 4.2.1H [M], and Section 4.2.2D and E [P]. The requirements are as follows:

   An **automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A four-hour manual override must be accessible to the occupants for off-hours operation.

   The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** (Section 4.2.1G)[M]. For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three complete air changes in not more than an hour, whichever is less.

   The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints [M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F.

   If the system serves multiple zones, the controls must include a **supply air temperature reset** function per Section 4.2.2G[P].

   Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down.

   When a unit serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down independently of each other per Section 4.2.1H[M]. Since most packaged units serve areas smaller than this, isolation can usually be accomplished by using automatic time switches for each unit or group of units.

9. **Heat pump thermostats and controls** must meet all of the requirements in items 7 and 8 above, and in addition must have controls [M]:

   a. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

   b. In which the cut-on and cut-off temperatures for compression heating are higher than the temperatures for supplementary heating.

   The controls may allow supplementary heating during:

   a. Defrost; and

   b. Transient periods such as start-up or raising the room thermostat setpoint if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

10. Ducts must be installed, sealed and insulated (Section 4.2.1J) [M] which follows UMC Sections 1002(b) and 1005.

B. Packaged VAV Reheat

A packaged variable air volume (VAV) system consists of a self-contained unit that uses a direct expansion coil and compressor(s) to cool the supply air, an optional heating section, and zones with individual VAV boxes. The package also includes a supply fan, condenser fan(s) and possibly return or exhaust fans. The compressor and condenser are normally integral to the system. The heating section may be either a gas furnace, a hot water coil, or a heat pump.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing**

must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. Any equipment listed in Table B-9 of Appendix B shall comply with the **listed efficiencies** [M].

3. **Design fan power consumption** must be no more than 1.25 Watts/cfm of supply air (Section 4.2.2C)[P]. The limit applies to the sum of the power of all supply, return, and exhaust fans in the space-conditioning system that operates during the peak design period, including toilet exhaust fans. This requirement does not apply to any fans that do not operate at peak, such as economizer exhaust fans. The limit does not apply to any system having fans totaling less than 25 horsepower (HP).

   If the system has fan-powered VAV boxes, the VAV box fan power is included if these fans run during the cooling peak.

   a. **Series box fans** must run continuously during occupied hours, so fan power is always included. If the box is sized to move more than the primary design supply quantity (induction ratio greater than 1.0), then the amount of additional plenum air supplied may be added to the total system supply cfm. Otherwise, the supply cfm is determined solely on the basis of the main supply fan.

Example 4-27: Series Fan-Powered Box

Question

How is the contribution to system fan power calculated for a series fan-powered VAV box having a primary air supply of 1,000 cfm, a total fan supply of 1,200 cfm, and a 450 watt fan?

Answer

Supply cfm cannot be double-counted. Since 1,000 cfm is being supplied by the main system fans, 1,200-1,000 = 200 cfm is contributed by the box fan, and may be added to the total system cfm.

Total system fan power is increased by 450 watts.

   b. **Parallel box fans** may or may not run continuously, depending on the designer's intent. If the fan runs only during periods of zone heating, then box cfm and power are excluded. If the fan runs continuously, then both fan airflow and power are taken into account.

Example 4-28: Parallel Fan-Powered Box

Question

How is the contribution to system fan power calculated for a parallel fan-powered box having a primary air supply of 1,000 cfm, a parallel fan supply of 300 cfm and a 1/15 HP motor? The box is part of a cold air distribution system (45 °F pimary supply temperature), and runs continuously to temper the supply air.

Answer

Since the 300 cfm contributed by the parallel fan is in addition to the primarily supply, total system supply is increased by 300 cfm.

The efficiency of a 1/15 horsepower motor is approximately 48 percent (Table B-8) and the direct drive efficiency is 1.0. Fan power is therefore:

(1/15 HP x 746 W/HP) / 0.48 = 104 watts

which is added to the total system power.

If instead the fan were controlled to operate only during zone heating, then both cfm and power would be excluded from the system calculations.

4. **Operating fan power consumption** of individual fans with motors 25 horsepower and larger shall be limited to no more than 30 percent of the design wattage at 50 percent design air volume (Section 4.2.2C) when static pressure set point equals 1/3 of the total design static pressure, based on certified manufacturer's test data. Mechanisms and controls shall be provided for this purpose.

Normally, fans of this size are either of the airfoil or vane-axial design. Airfoil fans riding the curve, using discharge dampers, or inlet vanes will not normally comply. Vane-axial fans require variable pitch blades to comply. Alternatively, a variable frequency drive can be used with either type of fan. Other fans, such as variable scroll fans may comply; manufacturer's data must be consulted.

5. **Ventilation** shall be in accordance with Section 4.2.1D - E [M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

   This quantity of outdoor air must be delivered at all times of occupancy; provisions must be incorporated in the system to maintain this constant ventilation rate as the supply airflow rate decreases in response to low cooling loads. Conference rooms or other spaces having dense but intermittent occupancy levels may require fan-powered VAV boxes, transfer fans or other mechanisms to accommodate their high ventilation requirements through the use of transfer air.

6. A fully integrated **economizer** with controls must be provided for each system delivering over 2,500 cfm supply air and 75,000 Btu/hr cooling (Section 4.2.2E) [P]. The economizer must be controlled such that its use does not overcool the mixed air and cause heating energy or reheat energy to increase.

   Economizers are not required in systems serving high-rise residential living quarters and hotel/motel guest rooms.

7. **Electric resistance heating** for reheat, etc. is prohibited in most circumstances (Section 4.2.2H) [P]. If supply air heating/cooling is provided by a heat pump specified with supplementary resistance heaters, the heat pump capacity using only the compressor must be at least 75 percent of the design heating load at design conditions[P].

8. **VAV Zone Controls** shall be in accordance with Section 4.2.1G and H [M], and Section 4.2.2E [P].

   For each zone, a thermostat must be provided to control the supply of heating and cooling [M]. Heating and cooling setpoints must be individually adjustable. The heating setpoint must be adjustable down to 55°F or lower (if reheat is provided), and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints.

   If no reheat is used, then a single setpoint zone thermostat may be used.

   Prior to reheating, recooling or mixing air, the controls must reduce the air supply to a flow no greater than the largest of [M]:

   a. 30 percent of the peak supply volume; or

   b. 0.4 cfm per square foot of conditioned floor area of the zone; or

   c. 300 cfm

   In addition, the minimum supply airflow must be equal to at least the minimum amount required to meet the ventilation requirements [M], unless some other means is provided to ensure outdoor ventilation at all times. Normally, the required minimum airflow will fall in a range bounded at the lower end by the ventilation requirement, and at the higher end by the reheat requirement. If the ventilation requirement is larger than the reheat requirement, then the reheat requirement is the same as the ventilation requirement.

   The VAV box controls should be able to measure the airflow rate and control the supply so that at least the minimum supply airflow rate is maintained at all times [M]. For this reason, VAV controls should of the **pressure independent** type; pressure dependent controls do not measure flow, and therefore should not be used.

Zonal VAV controls that reduce the airflow below the minimum ventilation rate more than 5 out of every 60 minutes cannot be used. For this reason, systems that alternately provide heated and cooled air to different zones through the same duct work cannot be used unless provisions are made to maintain the minimum ventilation rates (Section 4.2.2G) [M].

9. **System controls** shall be in accordance with Section 4.2.1H [M], 4.2.2D [P], and 4.2.2E [P]. The requirements are as follows:

   An **automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A 4-hour manual override must be accessible to the occupants for off-hours operation.

   The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** in accordance with Section 4.2.1. For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three complete air changes in no more than an hour, whichever is less.

   The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints [M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F.

   The controls must include a **supply air temperature reset** function per Section 4.2.2G [P]. Air flow rates to **interior zones** or other zones with relatively constant loads should be based on the fully reset temperature.

   When a unit serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down or set back independently of each other per Section 4.2.1H [M].

   Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down [M]. In addition, if ventilation air is provided through these dampers, the dampers must be controlled so that the minimum ventilation quantities are maintained during all times of occupancy [M]. The designer should refer to Section 4.2.1H for more information.

10. Systems using **heat pumps** for central heating must have controls [M]:

    a. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

    b. In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.

       The controls may allow supplementary heating during:

       i. Defrost; and

       ii. Transient periods such as start-up if the controls provide preferential rate control, intelligent recovery, staging, ramping, or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

11. **Ducts** must be installed, sealed and insulated per Section 4.2.1J [M]. Ducts must be insulated in compliance with UMC Section 1005. Higher insulation levels are encouraged, particularly when duct runs are very long, or run through unconditioned spaces.

12. Piping for unit hot water coils or reheat coils must be insulated in accordance with Section 4.2.1I[M].

C. Built-up VAV Reheat

Built-up VAV systems are thermodynamically similar to package VAV systems. While a packaged system is usually delivered and installed as a unit on the roof, a built-up system consists of individual components that are delivered to the site separately and are assembled within mechanical rooms. Supply air in a built-up system is commonly conditioned using hot and chilled water coils, although DX coils may also be used. A central boiler/chiller plant provides the working fluids to one or more air handling systems.

Hybrids of built-up and packaged systems also exist. For example a packaged unit may use a hot water coil for heating, that in turn is supplied with fluid from a central boiler. A built-up system may use a packaged air handler consisting of a fan, hot and chilled water coils, a filter section, and a mixing box all in one unit.

Because packaged and built-up VAV systems are thermodynamically similar, most of the requirements are the same. The following are the additional requirements for built-up systems:

1. The e**fficiency** of boilers and chillers shall be in accordance with Table B-9 in Appendix B [M].

2. **Pumps** are not specifically addressed by the *Standards*, except that the same sizing open, restrictions apply to pumps as to the rest of the heating and cooling system components (Section 4.2.2A).

D. Built-up Single-fan Dual-duct VAV

A single-fan, dual-duct VAV system consists of a blow-through fan whose discharge splits into a “hot deck” with a heating coil and a “cold deck” with a cooling coil. A pair of ducts delivers heated and cooled air to VAV mixing boxes in each zone. Each box modulates the flow of hot and cold air to its zone to maintain space temperature setpoint. The system will usually have an economizer, and return/exhaust fans may also be incorporated.

The original versions of this system were constant volume; heated and cooled air were proportionately mixed to maintain space temperature while the total volume of air delivered to the space remained constant. These constant-volume systems wasted large amounts of heating and cooling energy in the mixing process, and are effectively prohibited by the *Standards* with few exceptions.

The prescriptive *Standards* imply that dual-duct systems be variable-volume; cooling air must be reduced to a minimum before heating air is allowed to mix. In this configuration, a dual duct system may be more energy efficient than a VAV reheat because less heating energy is required. This is because, when the economizer is closed, part or all of the zone heating can be effectively accomplished using return air, allowing heating energy to be reduced or eliminated. When the economizer is heating energy increases, as the hot deck must heat cool mixed air rather than return air. During these times, heating energy usage is similar to a VAV reheat system.

As with VAV systems, hybrids of packaged and built-up dual duct systems exist. For example a packaged unit may use a hot water coil for heating, which in turn is supplied with fluid from a central boiler. A built-up system may use a packaged air handler consisting of a fan, hot and chilled water coils, a filter section and a mixing box all in one unit.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing** must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. The **efficiency** of boilers and chillers shall be in accordance with Appendix B, Table B-9 [M].

3. **Design fan power consumption** must be no more than 1.25 Watts/cfm of supply air(Section 4.2.2C) [P]. The limit applies to the sum of the power of all supply, return, and exhaust fans in the space-conditioning

system that operate during the peak design period, including toilet exhaust fans. This requirement does not apply to any fans that do not operate at peak, such as economizer exhaust fans. The limit does not apply to any system having fans totaling less than 25 horsepower.

4. **Operating fan power consumption** of individual fans with motors 25 horsepower and larger shall be limited to no more than 30 percent of the design wattage at 50 percent design air volume when static pressure set point equals 1/3 of the total design static pressure, based on certified manufacturer's test data (Section 4.2.2C) [P]. Mechanisms and controls shall be provided for this purpose.

   Normally, fans of this size are either of the airfoil or vane-axial design. Airfoil fans riding the curve, using discharge dampers, or inlet vanes, will not normally comply. Vane-axial fans require variable pitch blades to comply. Alternatively, a variable frequency drive can be used with either type of fan. Other fans, such as variable scroll fans may comply; manufacturer's data must be consulted.

5. **Pumps** are not specifically addressed by the *Standards*, except that the same sizing restrictions apply to pumps as to the rest of the heating and cooling system components (Section 4.2.2A).

6. **Ventilation** shall be in accordance with Section 4.2.1D through G[M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

   This quantity of outdoor air must be delivered at all times of occupancy; provisions must be incorporated in the system to maintain this constant ventilation rate as the supply airflow rate decreases in response to low cooling loads. The designer should refer to Section 4.2.1 for additional guidance.

   Conference rooms, or other spaces having dense but intermittent occupancy levels, may require fan-powered VAV boxes, transfer fans or other mechanisms to accommodate their high ventilation requirements through the use of transfer air.

7. A fully integrated **economizer** with controls must be provided for each system delivering over 2,500 cfm supply air and 75,000 Btu/hr cooling (Section 4.2.2F)[P]. The economizer must be controlled such that its use does not overcool the mixed air and cause hot deck heating energy to increase. To this effect, the mixed air setpoint must be reset on the basis of the warmest zone. In other words, the economizer should open to reduce the mixed air temperature only when a cooling load exists.

   Economizers are not required in systems serving high-rise residential living quarters and hotel/motel guest rooms.

8. **Electric resistance heating** for reheat, etc. is prohibited in most circumstances (Section 4.2.2H) [P].

9. **VAV Zone Controls** shall be in accordance with Section 4.2.1H [M] and Section 4.2.2D and E [P].

   For each zone, a **thermostat** must be provided to control the supply of heating and cooling [M].

   Heating and cooling setpoints must be individually adjustable. The heating setpoint must be adjustable down to 55°F or lower (if reheat is provided), and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints.

   Prior to reheating, recooling or mixing air, the controls must reduce the air supply to a flow no greater than the largest of [M]:

   a. 30 percent of the peak supply volume; or

b. 0.4 cfm per square foot of conditioned floor area of the zone; or

c. 300 cfm

In addition, the minimum supply airflow must be equal to at least the minimum amount required to meet the ventilation requirements [M], unless some other means is provided to ensure outdoor ventilation at all times. Normally, the required minimum airflow will fall in a range bounded at the lower end by the ventilation requirement, and at the higher end by the reheat requirement. If the ventilation requirement is larger than the reheat requirement, then the reheat requirement is the same as the ventilation requirement.

The VAV box controls must be able to measure the airflow rate and control the supply so that the minimum airflow rate is maintained at all times [M]. For this reason, VAV controls should be of the **pressure independent** type; pressure dependent controls do not measure flow, and therefore cannot be used.

10. **System controls** shall be in accordance with Section 4.2.1G and H [M], 4.2.2D [P], and 4.2.2E [P]. The requirements are as follows:

    An **automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A four-hour manual override must be accessible to the occupants for off-hours operation.

    The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** in accordance with Section 4.2.1G. For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three complete air changes in not more than an hour, whichever is less.

    The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints [M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F.

    The controls must include a **supply air temperature reset** function per Section 4.2.2G [P]. Both the hot deck and cold deck must incorporate the reset function. The controls should be capable of fully resetting the hot deck temperature from maximum design supply temperature down to return air temperature. Air flow rates to **interior zones** or other zones with relatively constant loads should be based on the fully reset temperature.

    A **mixed air temperature reset** should be included to minimize the impact of the economizer on the hot deck energy usage. This reset may be sequenced with the cold deck reset, or be reset on the basis of outdoor air temperatures or representative zone temperatures.

    When a unit serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down or set back independently of each other per Section 4.2.1H [M].

    Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down [M]. In addition, if ventilation air is provided through these dampers, the dampers must be controlled so that the minimum ventilation quantities are maintained during all times of occupancy [M]. The designer should refer to Section 4.2.1H for more information.

11. Ducts must be installed, sealed and insulated per Section 4.2.1J [M].

12. **Piping** for unit hot water coils or reheat coils must be insulated in accordance with Section 4.2.1I [M].

E. Dual-Fan Dual-Duct VAV

A dual-fan dual-duct VAV system is similar to a single-fan dual-duct VAV system except that the hot and cold decks each have their own fan .

This allows the hot deck to take air directly from the return while the cold deck is using economizer air. As a result, heating energy is minimized.

As with the single-fan dual-duct system, a pair of ducts delivers heated and cooled air to VAV mixing boxes in each zone. Each box modulates the flow of hot and cold air to its zone to maintain space temperature setpoint. The system will usually have an economizer on the cold deck; the hot deck may take air only from the return. Return/exhaust fans may also be incorporated.

The hot and cold decks may either be completely built-up, consist of air handlers with water coils, or be separate packaged units. For example, the hot deck may be a packaged rooftop gas furnace, and the cold deck may be a packaged rooftop DX unit.

Most of the requirements for the dual-fan dual-duct system are the same as for the single-fan dual-duct system. The following are the differences:

1. For dual fan systems, supply air flow includes the design cold deck supply, and the hot deck supply at the time of the cooling peak. Fan power is based on the design cold deck horsepower, and the hot deck fan power at the time of the cooling peak. Since the hot deck fan will normally be operating at a reduced air flow at the time of the cooling peak (or off), the hot deck fan horsepower may be determined on this basis. If unknown, the designer may assume that both hot deck airflow and power is 35 percent of design.

2. **Ventilation** may be delivered through the hot deck, the cold deck or both. If all ventilation air is provided through the cold deck, and the hot deck draws air only from the return, then the minimum cold duct cfm of the zone VAV box may be set to the required outdoor ventilation rate; the hot duct damper can close fully.

3. A fully integrated **economizer** with controls must be provided for each system delivering over 2,500 cfm supply air and 75,000 Btu/hr cooling [P]. This economizer may be on the cold deck only.

Example 4-29: Dual-Fan Dual-Duct Fan Power

Question

How is the fan power calculated for a dual-fan dual-duct VAV system having a 24,000 cfm, 25 BHP cold deck fan, and a 10,000 cfm, 9 BHP hot deck fan? Load calculations show that the hot deck will deliver 25 percent airflow at the time of the cooling peak. Both fans are modulated with variable frequency drives having efficiencies of 96 percent.

Answer

Assuming the belt drive efficiencies are 97 percent, and motor efficiencies are from Table B-8, the cold deck power is:

(25 BHP x 0.746kW/HP) / (0.88 x 0.97 x 0.96) = 22.8 kW

For the hot deck, assume that fan power will drop as the square of the airflow (the fan laws say the cube, but this is unrealistic). Power consumption at 25 percent airflow is then:

(9BHP x 0.746kW/HP) / (0.85 x 0.97 x 0.96) = 8.5 kW

8.5 kW x (2500cfm/10,000cfm)2 = 4.35 kW

Total power is:

22.8 kW + 4.3 kW = 27.0 kW

and total airflow is :

24,000 cfm + 2500 cfm = 26,500 cfm

so that system fan power is

(27.0 kW x 1000 W/kW) / 26,500 cfm = 1.0 W/cfm

4. **VAV Zone Controls** shall be in accordance with Section 4.2.1G and H [M] and Section 4.2.2 [P].

   The controls must be able to measure the airflow rate and control the supply so that the minimum airflow rate is maintained at all times [M]. For this reason, VAV controls should be of the **pressure independent** type; pressure dependent controls do not measure flow, and therefore should not be used. In a dual-duct VAV where all ventilation air is supplied through the cold duct, only the cold duct control need be pressure independent.

F. Packaged Terminal Air Conditioner with Gas-Furnace or Heat Pump

Packaged terminal air conditioners (PTAC) are units designed to supply heating and cooling to an individual space. They are usually smaller in capacity than packaged rooftop units, and are designed for through-the-wall installation. All PTAC units discharge air directly into the space without duct work. Cooling is provided by a compressor with direct expansion coil. Heating is provided by either using the compressor in a heat pump cycle or by a gas furnace. Units with electric resistance heating are also available, but their use is severely restricted by the *Standards*.

A PTAC unit is usually controlled directly by a thermostat that cycles the compressor on and off. This thermostat may be either integral to the unit or wall-mounted.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing** must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. Any **equipment** listed in Appendix B, Table B-9, shall comply with the listed efficiencies [M].

3. **Fan power consumption** is not regulated explicitly, as the requirements apply only to systems having fans 25 horsepower and larger.

4. **Ventilation** shall be in accordance with Section 4.2.1D - G [M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants may have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

   Conference rooms, or other spaces having dense but intermittent occupancy levels, may require transfer fans or other mechanisms to accommodate their increased ventilation requirements.

5. An **economizer** is not required for PTAC units under 2,500 cfm supply air and 75,000 Btu/hr cooling (Section 4.2.2F) [P]. Economizers are also not required for units serving residential living quarters and hotel/motel guest rooms.

6. With the exception of supplementary resistance heating as described below, **electric-resistance heating** (Section 4.2.2H) is permitted only where [P]:

   a. The total capacity of all electric resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating equipment serving the entire building; or

   b. The total capacity of all electric resistance heating systems serving the building, excluding supplementary resistance heaters in heat pumps, is less than 3 kW.

   In practical terms, these exceptions allow a building with a single small PTAC to use resistance heat instead of a heat pump. A large building may have a few PTACs with electric heat, provided that 90 percent of the building's heating capacity is provided by other types of units. Any other building heated and cooled by PTACs must use heat pump PTACs.

   When a PTAC is specified with supplementary resistance heaters, the heat pump compressor capacity must be at least 75 percent of the design heating load at design conditions per Section 4.2.2H [P].

7. **Zone Controls** shall be in accordance with Section 4.2.1H [M] and 4.2.2D [P].

   A **thermostat** must be provided to control heating and cooling to each zone [M]. The heating setpoint must be adjustable down to 55°F or lower, and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints, or the thermostat must be manually switched between heating and cooling.

   If the PTAC unit is serving a **hotel/motel guest room**, the thermostat must have numeric temperature setpoints in °F and stop points accessible only to authorized personnel [M].

   Ventilation air must be provided at least 55 out of every 60 minutes (4.2.1G) [M]. When outdoor air ventilation is provided mechanically, the **Auto/On** fan switch, if any, should be set to On.

8. **System controls** shall be in accordance with Section 4.2.1H [M], and 4.2.2D [P]. The requirements are as follows:

   A **certified automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A four-hour manual override must be accessible to the occupants for off-hours operation. Systems serving hotel/motel guest rooms are exempt provided they have a readily accessible manual shut-off switch

   The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** in accordance with Section 4.2.1G. For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three air changes in not more than one hour, whichever is less. Systems serving hotel/motel guest rooms are exempt.

   The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints (Section 4.2.1H)[M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F, or for hotel/motel guest rooms.

   Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down. Dampers are not required in hotel/motel guest rooms or other applications where exhaust fans run continuously.

   When a system serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down independently of each other [M]. Since PTAC units serve areas smaller than this, isolation is accomplished by using separate automatic time switches for each unit or group of units.

9. **Heat pump thermostats and controls** must meet all of the requirements in items 7 and 8 above, and in addition must have controls[M]:

   a. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

   b. In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.

   The controls may allow supplementary heating during:

   a. Defrost; and

   b. Transient periods such as start-up or raising the room thermostat setpoint if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

G. *Four-Pipe Fan Coil System with Central Plant*

A four pipe fan coil (FPFC) is a small unit consisting of a fan, separate heating and cooling coils, a replaceable filter and a drain pan for condensate. FPFCs are available in various configurations to fit under windowsills, above furred ceilings and in vertical spaces within walls. Ventilation air can be provided through the wall or via a central ventilating system.

A central plant, consisting of a hot water boiler and chiller, provides heating and cooling to the fan coil units.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing** must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. Any **equipment** listed in Appendix B, Table B-9, shall comply with the listed efficiencies [M].

3. **Fan power consumption** is not regulated explicitly, as the requirements apply only to systems having fans 25 horsepower and larger.

4. **Pumps** are not specifically addressed by the *Standards*, except that the same sizing restrictions apply to pumps as to the rest of the heating and cooling system components (Section 4.2.2A) [P].

5. Ventilation shall be in accordance with Section 4.2.1.D - G [M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants may have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

   Ventilation in through-the-wall units may be directly from the outdoors, although wind pressure may cause problems in this arrangement.

   When ventilation is via a central fan system, the duct work must deliver the required amount of air directly to each space. If the FPFC units are above the ceiling in a return plenum, then the ventilation air supply must be either directly connected to the unit or ducted to discharge either:

   a. Within 5 feet of the unit; or

   b. Within 15 feet of the unit, with the air directed substantially toward the unit, and with a discharge velocity of at least 500 feet per minute (Section 4.2.1F).

6. An **economizer** is not required for FPFC units under 2,500 cfm supply air and 75,000 Btu/hr cooling [P]. Economizers are also not required for units serving residential living quarters and hotel/motel guest rooms.

   Water-side economizers should be evaluated for buildings in favorable climates.

7. **Electric resistance heating** for local heating, etc. is prohibited in most circumstances [P]. The designer should refer to Section 4.2.2H for the exceptions.

8. **Zone Controls** shall be in accordance with Section 4.2.1H [M] and 4.2.2D [P].

   A **thermostat** must be provided to control heating and cooling to each zone [M]. The heating setpoint must be adjustable down to 55°F or lower, and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints, or the thermostat must be manually switched between heating and cooling.

   Ventilation air must be provided at least 55 out of every 60 minutes (4.2.1G) [M]. When outdoor air ventilation is provided mechanically, the **Auto/On** fan switch, if any, should be set to **On**. This is not required if a central system is used to deliver ventilation air independent of unit fan operation.

9. **System controls** shall be in accordance with Section 4.2.1G and H[M], and 4.2.2D and E. [P]. The requirements are as follows:

   An **automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A four-hour manual override must be accessible to the occupants for off-hours operation.

   The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** in accordance with Section 4.2.1G*.* For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three air changes per hour, whichever is less. If a central ventilation system is used to supply ventilation air directly to the space, then unit fans do not need to be started ahead of time.

   The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints [M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F.

   Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down. Dampers are not required in hotel/motel guest rooms or other applications where exhaust fans will operate continuously.

   When a system serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down independently of each other [M]. Since FPFC units serve areas smaller than this, isolation is accomplished by using separate automatic time switches for each unit or group of units.

10. **Ducts, if any,** must be installed, sealed and insulated per Section 4.2.1J [M]. Ducts must be insulated in compliance with UMC Section 1005 or Section 4.2.1J [M].

11. **Piping** for unit hot and chilled water coils must be insulated in accordance with Section 4.2.1.I [M].

H. Water Loop Heat Pump System with Central Plant

Water loop heat pumps (WLHP) provide heating and cooling for a number of individually controlled zones by operation of water-to-air heat pump units located in each space. Each heat pump is piped to a common circulation loop and will take heat from, or reject heat to the loop, depending on whether the unit is in the heating or cooling mode.

During some periods, the thermal requirements of units in the heating mode will balance with the units in the cooling mode, and the loop will remain at a constant temperature. At other times the loop will be out of balance, and heat must be made up by a boiler or rejected by a cooling tower.

WLHPs are available in various sizes and configurations to fit under windowsills, above furred ceilings, stacked in vertical spaces within walls, in mechanical rooms, and on rooftops. Small units are often used for each exterior space, with larger units serving the interior.

Ventilation air can be provided through the wall in perimeter units, or via a central ventilating system.

A central plant, consisting of a hot water boiler and cooling tower, provides supplemental heating and heat rejection for the loop.

The requirements for this system are as follows:

1. **Load calculations** must be in accordance with Section 4.2.2B, and **equipment sizing** must be in accordance with Section 4.2.2A [P]. Allowable safety factors and pick-up factors may be applied.

2. Any **equipment** listed in Appendix B, Table B-9, of Appendix B shall comply with the listed efficiencies [M]**.**

3. **Fan power consumption** must be no more than 0.8 Watts/cfm of supply air for constant volume systems, in accordance with Section 4.2.2C [P]. The limit applies to the sum of the horsepower of all supply, return, and exhaust fans in the space-conditioning system that operates during the peak design period. Space exhaust fans such as toilet exhausts are included, while economizer fans that do not operate at peak are excluded.

   The limit does not apply to any system having fans totaling less than 25 HP. Because most WLHP systems are relatively small, fan horsepower will not usually be a consideration.

4. **Pumps** are not specifically addressed by the *Standards*, except that the same sizing restrictions apply to pumps as to the rest of the heating and cooling system components (Section 4.2.2A).

5. **Ventilation** shall be in accordance with Section 4.2.1C [M]. For most office spaces, a minimum of 0.15 cfm/sf or 15 cfm/person, whichever is greater, shall apply. Areas with unusual sources of contaminants may have additional requirements. Natural ventilation may be used in place of mechanical ventilation in spaces having sufficient access to the outdoors through operable windows.

   Ventilation in through-the-wall units may be directly from the outdoors, although wind pressure may cause problems in this arrangement.

   When ventilation is via a central fan system, the duct work must deliver the required amount of air directly to each space. If the WLHP units are above the ceiling in a return plenum, then the ventilation air supply must be either directly connected to the unit or ducted to discharge either:

   a. Within five feet of the unit; or

   b. Within 15 feet of the unit, with the air directed substantially toward the unit, and with a discharge velocity of at least 500 feet per minute (Section 4.2.1F).

6. A fully integrated **economizer** with controls must be provided for each system delivering over 2,500 cfm supply air and 75,000 Btu/hr cooling (Section 4.2.2F)[P]. A water economizer must meet 100 percent of the expected system cooling load as calculated at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

7. **Electric resistance heating** for local heating, etc. is prohibited in most circumstances [P]. The designer should refer to Section 4.2.2H for the exceptions.

   Electric boilers for supplemental loop heating are not allowed unless it can be demonstrated to the satisfaction of the enforcement agency that at least 60 percent of the annual heating energy requirement is supplied by site solar or recovered energy.

8. **Zone Controls** shall be in accordance with Section 4.2.1H [M] and 4.2.2D [P].

   A **thermostat** must be provided to control heating and cooling to each zone [M]. The heating setpoint must be adjustable down to 55°F or lower, and the cooling setpoint up to 85°F or higher. There must be at least a 5°F deadband between heating and cooling setpoints, or the thermostat must be manually switched between heating and cooling.

   Ventilation air must be provided at least 55 out of every 60 minutes (Section 4.2.1G) [M]. When outdoor air ventilation is provided mechanically, the **Auto/On** fan switch, if any, should be set to **On**. This is not required if a central system is used to deliver ventilation air independently of unit fan operation.

9. **System controls** shall be in accordance with Section 4.2.1G and H [M], and 4.2.2D [P]. The requirements are as follows:

An **automatic time switch** with weekday/weekend features shall start and stop the equipment [M]. A four-hour manual override must be accessible to the occupants for off-hours operation.

The controls must start the system sufficiently ahead of occupancy and operate the system to accomplish a **building purge** in accordance with Section 4.2.1G. For office buildings, the purge requirement is one hour at the minimum ventilation rate, or three complete air changes, whichever is less. If a central ventilation system is used to supply ventilation air directly to the space, then unit fans do not need to be started ahead of time.

The controls must restart the system during unoccupied times to maintain **heating setback/cooling setup** setpoints (Section 4.2.1H) [M]. Heating setback control is not required where winter design temperatures are above 32°F; cooling setup control is not required where summer design temperatures do not exceed 100°F.

Outdoor air supply and exhaust equipment shall have **dampers** that automatically close during periods the equipment is shut down.

When a system serves more than 25,000 square feet, **isolation devices** must be incorporated so that areas of no more than 25,000 square feet can be shut down independently of each other [M]. Since WLHP units normally serve areas smaller than this, isolation is accomplished by using separate automatic time switches for each unit or group of units.

10. **Ducts, if any** must be installed, sealed and insulated per Section 4.2.1J [M].

11. **Piping** must be insulated in accordance with Section 4.2.1I [M]. Note that piping for WLHPs will not normally need to be insulated.

4.3 MECHANICAL PLAN CHECK DOCUMENTS

At the time a building permit application is submitted to the building department, the applicant also submits plans and energy compliance documentation. This section describes the forms and recommended procedures documenting compliance with the mechanical requirements of the *Standards*. It does not describe the details of the requirements; these are presented in Section 4.2 Mechanical Design Procedures. The following discussion is addressed to the designer preparing construction documents and compliance documentation, and to the building department plan checkers who are examining those documents for compliance with the *Standards*.

The use of each form is briefly described below, then complete instructions for each form are presented in the following subsections. The information and format of these forms may be included in the equipment schedule.

MECH-1: Certificate of Compliance
This form is required for every job, and it is required to appear *on the plans*.

MECH-2: Mechanical Equipment Summary
This form summarizes the major components of the heating and cooling systems, and documents compliance with the minimum efficiency, economizer and VAV airflow requirements.

MECH-3: Mechanical Ventilation
This form documents the calculations used as the basis for the outdoor air ventilation rates. For VAV systems, it is also used to show compliance with the reduced airflow rates necessary before reheating, recooling or mixing of conditioned airstreams.

MECH-4: Mechanical Sizing and Fan Power
This form is used to list the size of all equipment regulated by these *Standards*, and to document compliance with the fan power limitations.

4.3.1 MECH-1: Certificate of Compliance

MECH-1 is the primary mechanical form. Its purpose is to provide compliance information in a form useful to the enforcement agency's field inspectors.

This form should be included on the plans, usually near the front of the mechanical drawings. A copy of these forms should also be submitted to the building department along with the rest of the compliance submittal at the time of building permit application. With building department approval, the applicant may use alternative formats of these forms (rather than the Energy Commission's forms), provided the information is the same and in similar format. Additionally, if none of the information requested for Part 2 of 2 of this form applies to the job, the building department does not have to require that these parts be included on the plans.

A. Project Description

1. **PROJECT NAME** is the title of the project, as shown on the plans and known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

3. **PROJECT ADDRESS** is the address of the project as shown on the plans and known to the building department.

4. **PRINCIPAL DESIGNER - MECHANICAL** is the person responsible for the preparation of the mechanical plans, and the person who signs the STATEMENT OF COMPLIANCE (see below). The person's telephone number is given to facilitate response to any questions that arise.

5. **DOCUMENTATION AUTHOR** is the person who prepared the energy compliance documentation. This may or may not be the principal designer (it may be a person specializing in *Standards* compliance work). The person's telephone number is given to facilitate response to any questions that arise..

6. **ENFORCEMENT AGENCY USE** is reserved for building department record keeping purposes.

B. General Information

1. **DATE OF PLANS** is the last revision date of the plans. If the plans are revised after this date, it may be necessary to re-submit the compliance documentation to reflect the altered design. The building department will determine whether or not the revisions require this.

2. **BUILDING CONDITIONED FLOOR AREA** has specific meaning under the *Standards*. See Section 2.1.2A for a discussion of this definition.

   The number entered here should match the floor area entered on form ENV-1.

3. **BUILDING TYPE** is specified because there are special requirements for high-rise residential and hotel/motel guest room occupancies. All other occupancies that fall under the *Nonresidential Standards* are designated "Nonresidential" here. It is possible for a building to include more than one building type. See Section 2.1.2B for the formal definitions of these occupancies.

4. **PHASE OF CONSTRUCTION** indicates the status of the building project described in the documents. Refer to Section 2.2 for detailed discussion of the various choices.

   a. **NEW CONSTRUCTION** should be checked for all new buildings (see Section 2.2.6), newly conditioned space (see Section 2.2.2) or for new construction in existing buildings (tenant improvements, see Section 2.2.3) which are submitted for envelope compliance.

   b. **ADDITION** should be checked for an addition which is not treated as a standalone building, but which uses Option 2 described in Section 2.2.5.

c. **ALTERATION** should be checked for alterations to existing building mechanical systems (see Section 2.2.4).

5. **METHOD OF MECHANICAL COMPLIANCE** indicates which method is being used and documented with this submittal:

   a. **PRESCRIPTIVE** should be checked if the mechanical systems comply using only the mandatory and prescriptive measures.

   b. **PERFORMANCE** should be checked when the performance method is used to show compliance. All required performance documentation must be included in the plan check submittal when this method is used.

6. **PROOF OF ENVELOPE COMPLIANCE** indicates how the envelope has been shown to comply. The envelope must comply before a permit to install a mechanical system is granted:

   a. **PREVIOUS ENVELOPE PERMIT** indicates that the envelope has already been shown to comply. If so, the building department will have the envelope forms on file. This method is typically used for alterations to existing space.

   b. **ENVELOPE COMPLIANCE ATTACHED** - is typically used for new buildings.

C. Statement of Compliance

The Statement of Compliance is signed by both the Documentation Author (described above in section 4.3.1.A.) and the person responsible for preparation of the plans for the building. This latter person is also responsible for the energy compliance documentation, even if the actual work is delegated to a different person acting as Documentation Author. It is necessary that the compliance documentation be consistent with the plans. The Business and Professions Code governs who is qualified to prepare plans, and therefore to sign this statement; check the appropriate box that describes the signer's eligibility.

Applicable sections from the *Business and Professions Code*, referenced on the Certificate of Compliance, are provided below:

Applicable sections from the *Business and Professions Code* (based on the edition in effect as of April 1998), referenced on the Certificate of Compliance are provided below:

5537. *(a) This chapter does not prohibit any person from preparing plans, drawings, or specifications for any of the following:*

(1) Single-family dwellings of woodframe construction not more than two stories and basement in height.

(2) Multiple dwellings containing no more than four dwelling units of woodframe construction not more than two stories and basement in height. However, this paragraph shall not be construed as allowing an unlicensed person to design multiple clusters of up to four dwelling units each to form apartment or condominium complexes where the total exceeds four units on any lawfully divided lot.

(3) Garages or other structures appurtenant to buildings described under subdivision (a), of woodframe construction not more than two stories and basement in height.

(4) Agricultural and ranch buildings of woodframe construction, unless the building official having jurisdiction deems that an undue risk to the public health, safety, or welfare is involved.

(b) If any portion of any structure exempted by this section deviates from substantial compliance with conventional framing requirements for woodframe construction found in the most recent edition of Title 24 of the California Code of Regulations or tables of limitation for woodframe construction, as defined by the applicable building code duly adopted by the local jurisdiction or the state, the building official having jurisdiction shall require the preparation of plans, drawings, specifications, or calculations for that portion by, or under the responsible control of, a licensed architect or registered engineer. The documents for that portion shall bear the stamp and signature of the licensee who is responsible

for their preparation. Substantial compliance for purposes of this section is not intended to restrict the ability of the building officials to approve plans pursuant to existing law and is only intended to clarify the intent of Chapter 405 of the Statutes of 1985.

5537.2. *This chapter shall not be construed as authorizing a licensed contractor to perform design services beyond those described in Section 5537 or in Chapter 9 (commencing with Section 7000), unless those services are performed by or under the direct supervision of a person licensed to practice architecture under this chapter, or a professional or civil engineer licensed pursuant to Chapter 7 (commencing with Section 6700) of Division 3, insofar as the professional or civil engineer practices the profession for which he or she is registered under that chapter.*

However, this section does not prohibit a licensed contractor from performing any of the services permitted by Chapter 9 (commencing with Section 7000) of Division 3 within the classification for which the license is issued. Those services may include the preparation of shop and field drawings for work which he or she has contracted or offered to perform, and designing systems and facilities which are necessary to the completion of contracting services which he or she has contracted or offered to perform.

However, a licensed contractor may not use the title "architect," unless he or she holds a license as required in this chapter.

5538. *This chapter does not prohibit any person from furnishing either alone or with contractors, if required by Chapter 9 (commencing with Section 7000) of Division 3, labor and materials, with or without plans, drawings, specifications, instruments of service, or other data covering such labor and materials to be used for any of the following:*

(a) For nonstructural or nonseismic storefronts, interior alterations or additions, fixtures, cabinetwork, furniture, or other appliances or equipment.

(b) For any nonstructural or nonseismic work necessary to provide for their installation.

(c) For any nonstructural or nonseismic alterations or additions to any building necessary to or attendant upon the installation of those storefronts, interior alterations or additions, fixtures, cabinetwork, furniture, appliances, or equipment, provided those alterations do not change or affect the structural system or safety of the building.

6737.1. *(a) This chapter does not prohibit any person from preparing plans, drawings, or specifications for any of the following:*

(1) Single-family dwellings of woodframe construction not more than two stories and basement in height.

(2) Multiple dwellings containing no more than four dwelling units of woodframe construction not more than two stories and basement in height. However, this paragraph shall not be construed as allowing an unlicensed person to design multiple clusters of up to four dwelling units each to form apartment or condominium complexes where the total exceeds four units on any lawfully divided lot.

(3) Garages or other structures appurtenant to buildings described under subdivision (a), of woodframe construction not more than two stories and basement in height.

(4) Agricultural and ranch buildings of woodframe construction, unless the building official having jurisdiction deems that an undue risk to the public health, safety or welfare is involved.

(b) If any portion of any structure exempted by this section deviates from substantial compliance with conventional framing requirements for woodframe construction found in the most recent edition of Title 24 of the California Administrative Code or tables of limitation for woodframe construction, as defined by the applicable building code duly adopted by the local jurisdiction or the state, the building official having jurisdiction shall require the preparation of plans, drawings, specifications, or calculations for that portion by, or under the direct supervision of, a licensed architect or registered engineer. The documents for that portion shall bear the stamp and signature of the licensee who is responsible for their preparation.

6737.3. *A contractor, licensed under Chapter 9 (commencing with Section 7000) of Division 3, is exempt from the provisions of this chapter relating to the practice of electrical or mechanical engineering so long as the services* *he or she holds himself or herself out as able to perform or does perform, which services are subject to the provisions of this chapter, are performed by, or under the responsible supervision of a registered electrical or mechanical engineer insofar as the electrical or mechanical engineer practices the branch of engineering for which he or she is registered.*

This section shall not prohibit a licensed contractor, while engaged in the business of contracting for the installation of electrical or mechanical systems or facilities, from designing those systems or facilities in accordance with applicable construction codes and standards for work to be performed and supervised by that contractor within the classification for which his or her license is issued, or from preparing electrical or mechanical shop or field drawings for work which he or she has contracted to perform. Nothing in this section is intended to imply that a licensed contractor may design work which is to be installed by another person

D. Mechanical Mandatory Measures

The Mandatory Measures must be incorporated into the construction documents. The designer may use whatever format is most appropriate for specifying the mandatory measures in the plan set. In general, this will take the form of a notes block near the front of the set, possibly with cross-references to other locations in the plans where measures are specified. This space should be used to indicate the sheet number(s) on the plans where these notes can be found.

A sample, generic mechanical mandatory measures note block is shown in Example 4-30. This particular format allows the designer to check the appropriate boxes to indicate the applicable mandatory measures.

Example 4-30: Sample Notes - Mechanical Mandatory Measures

Equipment and Systems Efficiency

- Any appliance for which there is a California standard established in the Appliance Efficiency Standards may be installed only if the manufacturer has certified to the Energy Commission, as specified in those regulations, that the appliance complies with the applicable standard for that appliance. Included are room air conditioners, central air conditioning heat pumps (regardless of capacity, except that requirements for central air conditioning heat pumps with cooling capacity of 135,000 Btu/hr or more apply to heating performance but not cooling performance), other central air conditioners with a cooling capacity less than 135,000 Btu/hr, fan type central furnaces with input rate less than 400,000 Btu/hr, boilers wall furnaces, floor furnaces, room heaters, unit heaters and duct furnaces shall have been certified to the Energy Commission by its manufacturer to comply with the Appliance Efficiency Standards.

- The following space-conditioning equipment may be installed only if the manufacturer has certified that the equipment meets or exceeds all applicable efficiency requirements listed in Section 112 of the *Standards*: all air conditioners, heat pumps and condensing units >135,000 Btu/hr; all water chillers; all gas-fired boilers >300,000 Btu/hr; all oil-fired boilers >225,000 Btu/hr; and all warm air furnaces and combination warm air furnaces/air-conditioning units >225,000 Btu/hr. Fan type central furnaces shall not have a pilot light.

- Piping, except those conveying fluids at temperatures between 60°F and 105°F, or within HVAC equipment, shall be insulated in accordance with *Standards* Section 123.

- Air handling duct systems shall be constructed, installed, sealed and insulated as provided in Chapter 10 of the Uniform Mechanical Code.

Controls

- Each space-conditioning system serving building types such as offices and manufacturing facilities (and all others not explicitly exempt from the requirements of Section 112(d)) shall be installed with an automatic time switch with an accessible manual override that allows operation of the system during off-hours for up to four hours. The time switch shall be capable of programming different schedules for weekdays and weekends; and has program backup capabilities that prevent the loss of the device's program and time setting for at least 10 hours if power is interrupted.

- Each space-conditioning system shall be installed with an occupancy sensor to control the operating period of the system.

- Each space-conditioning system shall be installed with a four-hour timer that can be manually operated to control the operating period of the system.

- Each space-conditioning system shall be installed with controls that temporarily restart and temporarily operate the system as required to maintain a setback heating thermostat setpoint.

- Each space-conditioning system shall be installed with controls that temporarily restart and temporarily operate the system as required to maintain a setback cooling thermostat setpoint.

- Each space-conditioning system serving multiple zones with a combined conditioned floor area more than 25,000 square feet shall be provided with isolation zones. Each zone shall:

Example 4-30: Sample Notes (cont'd)

- ‣ not exceed 25,000 square feet; shall be provided with isolation devices, such as valves or dampers, that allow the supply of heating or cooling to be

- ‣ setback or shut off independently of other isolation areas; and shall be controlled by a time control device as described above.

- Each space-conditioning zone shall be controlled by an individual thermostatic control that responds to temperature within the zone. Where used to control heating, the control shall be adjustable down to 55°F or lower. For cooling, the control shall be adjustable up to 85°F or higher. Where used to control both heating and cooling, the control shall be capable of providing a dead band of at least 5°F within which the supply of heating and cooling is shut off or reduced to a minimum.

- Thermostats shall have numeric setpoints in °F.

- Thermostats shall have adjustable setpoint stops accessible only to authorized personnel.

- Heat Pumps shall be installed with controls to prevent electric resistance supplementary heater operation when the heating load can be met by the heat pump alone. Electric resistance supplementary heater operation is permitted during transient periods, such as start-ups and following room thermostat setpoint advance, when controls are provided which use preferential rate control, intelligent recovery, staging, ramping, or similar control mechanisms designed to preclude the unnecessary operation of supplementary heating during the recovery period. Supplementary heater operation is also permitted during defrost.

Ventilation

- Controls shall be provided to allow outside air dampers or devices to be operated at the ventilation rates as specified in these plans.

- Gravity or automatic dampers interlocked and closed on fan shutdown shall be provided on the outside air intakes and discharges of all space-conditioning and exhaust systems.

- All gravity ventilating systems shall be provided with automatic or readily accessible manually operated dampers in all openings to the outside, except for combustion air openings.

Completion and Balancing

- All ventilation systems shall be documented per California Safety Code (Title 8, Section 5142(b)) to be providing the minimum required ventilation rate as determined using one of the following procedures:

  (1) Air Balancing: all space-conditioning and ventilation systems shall be balanced to the quantities specified in these plans, in accordance with the National Environmental Balancing Bureau (NEBB) Procedural Standards (1983), or Associated Air Balance Council (AABC) National Standards (1989).

  (2) Outside Air Certification: The system shall provide the minimum outside air as shown on the mechanical drawings, and shall be measured and certified by the installing licensed C-20 mechanical contractor.

  (3) Outside Air Measurement: The system shall be equipped with a calibrated local or remote device capable of measuring the quantity of outside air on a continuous basis and displaying that quantity on a readily accessible display device.

  (4) Another method approved by the Energy Commission.

Service Water Heating Systems

- The following service water heating systems and equipment may be installed only if the manufacturer has certified that the equipment meets or exceeds all applicable efficiency requirements listed in the *Appliance Efficiency Regulations* or Appendix B, Table B-9.

Example 4-30: Sample Notes (cont'd)

- Unfired service water heater storage tanks and backup tanks for solar water heating systems shall have either:
  - external insulation with an installed R-value of at least R-12; internal and external insulation with a combined R-value of at least R-16; or
  - sufficient insulation so that the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu/hr/sf.
- If a circulating hot water system is installed, it shall have a control capable of automatically turning off the circulating pump(s) when hot water is not required.
- Lavatories in restrooms of public facilities shall be equipped with either:
  - Outlet devices that limit the flow of hot water to a maximum of 0.5 gallons per minute
  - Foot actuated control valves, and outlet devices that limit the flow of hot water to a maximum of 0.75 gallons per minute.
  - Proximity sensor actuated control valves, and outlet devices that limit the flow of hot water to a maximum of 0.75 gallons per minute.
  - Self-closing valves, and outlet devices that limit the flow of hot water to a maximum of 2.5 gallons per minute, and 0.25 gallons/cycle (circulating system).
  - Self-closing valves, and outlet devices that limit the flow of hot water to a maximum of 2.5 gallons per minute, and 0.50 gallons/cycle (non-circulating system).
  - Self-closing valves, and outlet devices that limit the flow of hot water to a maximum of 2.5 gallons per minute, and 0.75 gallons/cycle (foot switches and proximity sensor controls).
- Lavatories in restroom of public facilities shall be equipped with controls to limit the outlet temperature to 110°F.

Pools and Spas

- Pool and/or spa heating systems or equipment shall be installed only if the manufacturer has certified that the system or equipment meets the requirements of Sections 114 and 115 of the *Standards*. Equipment shall not have a pilot light. All such systems shall be installed with at least 36 inches of pipe between the filter and the heater to allow for the future addition of solar heating equipment.
- A cover shall be provided for outdoor pools.
- A cover shall be provided for outdoor spas.
- Pools shall be installed with directional inlets that adequately mix the pool water.
- Pool circulation pump(s) shall be provided with a time switch that allows the pump to be set to run in the off-peak electrical demand period, and for the minimum time necessary to maintain the water in the conditions required by applicable public health standards.

To verify certification, use one of the following options:

1. The Energy Hotline (see above) can verify certification of appliances not found in the above directories.
2. The Energy Commission's Web Site includes listings of energy efficient appliances for several appliance types. The web site address is www.energy.ca.gov/efficiency/appliances.
3. The complete appliance databases can be downloaded from the Energy Commission's internet FTP site (FTP://sna.com/pub/users/efftech/appliance/). This requires database software (spreadsheet programs cannot handle some of the larger files). To use the data, a user must download the database file (or files), download a brand file and a manufacturer file and then decompress

these files. Then download a description file that provides details on what is contained in each of the data fields. With these files, and using database software, the data can be sorted and manipulated.

4. The Air Conditioning and Refrigeration Institute (ARI) Directory of Certified Unitary Products and Directory of Certified Applied Air-Conditioning Products can be used to verify certification of air-conditioning equipment.

E. System Features

This section is used to identify the mandatory and prescriptive features that will be verified by the field inspector. The form has columns for up to 3 systems. Additional forms should be attached for additional systems. When systems are identical, a single column may be used, and all systems listed in the **SYSTEM NAME** field. A **CODE TABLE** found toward the bottom of the form lists the acceptable entries. Either the abbreviation or the full entry is acceptable. Fields that are not applicable may be left blank or designated “N/A”.

1. **SYSTEM NAME** is the name of the system as shown on the plans.

2. **TIME CONTROL** indicates the type of time control device for this system:

   S Programmable time switch with weekday/weekend features.

   O Occupancy sensor, for intermittently occupied spaces only

   M Manual timer, for intermittently occupied spaces only

3. **SETBACK CONTROL** indicates whether controls which can restart the equipment based on space temperature during off-hours are required:

   H Heating: Required if design heating temperature is less than 32°F

   C Cooling: Required if design cooling temperature is greater than 100°F

   B Both

4. **ISOLATION ZONES** indicates the number of isolation zones that are required when the area served by a single HVAC system exceeds 25,000 square feet.

5. **HEAT PUMP THERMOSTAT** indicates that the system incorporates a heat pump which will be directly controlled by a heat pump thermostat which minimizes the use of electric resistance heat.

6. **ELECTRIC HEAT** indicates whether any electric heat is approved for this system. The capacity in kW and the location (system, room number, etc.) should be indicated in the field notes.

7. **FAN CONTROL** indicates the type of modulation the supply and return fans will have in a variable air volume system. For fan systems over 25 hp, the modulation must achieve at least a 50 percent power reduction at 70 percent airflow. The choices are:

   C for a fan that rides the curve. This is suitable only for forward-curved fans.

   I for inlet vanes. Normally, this is suitable only for forward-curved fans. If used with airfoil/backward inclined fans, manufacturer’s data showing a 70 percent power reduction at 50 percent airflow must be attached to the form.

   P for variable pitch vanes.

   V for variable frequency drive or variable-speed drive.

   O for other. Manufacturer’s data showing a 70 percent power reduction at 50 percent airflow must be attached to the form.

8. **VAV MIN POSITION CONTROL** is used for variable air volume systems only, and indicates that the plans must include a schedule of VAV boxes showing the minimum required airflow to each space.

9. **SIMULTANEOUS HEAT/COOL** indicates that a constant-volume type system will be using simultaneous heating and cooling in order to serve a space with special requirements (humidity control, constant ventilation, etc.)

   If the system serves more than one space, the field notes should indicate the spaces in which this is allowed.

10. **HEAT AND COOL SUPPLY RESET** is required for systems which reheat, recool, or mix conditioned air streams, and indicates that a supply air temperature reset must be incorporated into the control sequences.

11. **VENTILATION** indicates the manner in which compliance with the ventilation requirements will be achieved:

    B **Air Balance**: Indicates that an air balance will be made by a certified air balance contractor. The inspector should ask to see a copy of the balance report.

    C **Outside Air Certification**: Indicates that the installing licensed C-20 mechanical contractor will measure the outdoor airflow and adjust the system and controls so that the minimum required outdoor ventilation rate is delivered under all operating conditions. A statement indicating that the system provides the minimum outside air as shown on the mechanical drawings must be signed by either the design mechanical engineer, the installing licensed C-20 contractor, or the person with overall responsibility for the design of the ventilation system. The certificate must be presented to the inspector before an occupancy permit is granted.

    M **Measurement**: The system will be equipped with a calibrated device capable of measuring the quantity of outside air and displaying the value.

    D **Demand Control**: The system will be equipped with a demand control ventilation device which will be installed and adjusted to control carbon dioxide (CO_2) levels.

    N **Natural Ventilation**: Operable openings will provide natural ventilation.

12. **OUTDOOR DAMPER CONTROL** indicates the type of controls used to close system intake and exhaust dampers during off hours:

    A **Automatic** motorized damper controls

    G **Gravity** type backdraft dampers

13. **ECONOMIZER TYPE** is used to indicate whether a space-conditioning system has an economizer, and the type. The choices are **AIR**, **WATER** or **N/A**.

14. **DESIGN O.A. AIR CFM** indicates the minimum airflow that the space-conditioning system must continuously provide during all occupied hours (from MECH-3, Column H).

15. **HEATING EQUIPMENT TYPE** identifies the type of heating equipment that the field inspector will check for this system. Generic entries such as Boiler or Gas Furnace are acceptable. See Appendix B, Table B-9

    a. **HIGH EFFICIENCY** indicates that the equipment installed has an efficiency higher than required by the *Standards*, and that this higher efficiency was used in the Performance Method to demonstrate compliance with the *Standards*.

       This box should also be checked when higher efficiency equipment is installed as part of a utility rebate program.

    b. **IF YES ENTER EFF. #** if the **HIGH EFFICIENCY** box is checked enter the equipment efficiency and unit here (i.e. AFUE, Thermal EFF, COP).

    c. **MAKE AND MODEL NUMBER** is for the heating equipment identified on the previous line. This entry should match the entry listed on the MECH-2 form. It is recognized that the actual make and model of equipment installed is often different from that specified. If so, and if **HIGH EFFICIENCY** is indicated, the substitute equipment must be at least as efficient as the equipment originally specified. Enter the equipment efficiency and unit here (i.e. AFUE, Thermal EFF, COP).

Manufacturer's performance data for substitute equipment must be resubmitted to the building department for approval. Upon reapproval, the building department should make notes to that effect in the **NOTE TO FIELD** column.

16. **COOLING EQUIPMENT TYPE** is identical to HEATING EQUIPMENT TYPE described above. Note that, when substitute HIGH EFFICIENCY. equipment is used, the equipment must satisfy all specified efficiency indicators, including SEER, EER, IPLV, etc. See Appendix B, Table B-9

17. **PIPE INSULATION REQUIRED** should list the function of the pipe when pipe insulation is required. Appropriate entries might be supply, return, nonrecirculating or recirculating (for service water), chilled supply, etc.

18. **PIPE TYPE** is supply, return, etc.

19. **HEATING DUCT LOCATION** indicates the location of the duct work for the purposes of establishing the ambient temperature. Most common locations include:

    a. **Conditioned** - for duct work located directly within the conditioned space.

    b. **Plenum** - for duct work located above a ceiling, but below an insulated roof

    c. **Attic** - for duct work located above an insulated ceiling, and below an uninsulated roof.

    d. **Unconditioned** - for duct work running through spaces that are not conditioned.

    e. **Roof** - for duct work exposed on a roof.

20. **DUCT R-VALUE** is the required R-value of the duct insulation, based on duct location and climate. If the designer has specified a higher R-value, the higher value should be entered instead.

21. **COOLING DUCT LOCATION/DUCT R-VALUE** is identical to HEATING DUCT LOCATION and DUCT R-VALUE.

22. **DUCT TAPE ALLOWED?** Indicate a Yes or No as to whether pressure-sensitive duct tape is used.

F. Notes To Field

This column is for building department use. It is intended as a communication mechanism between the plan checker and field inspector. The plan checker should note any critical or unusual details that are important to the building's energy compliance.

G. Sample Form: MECH-1 Certificate of Compliance

CERTIFICATE OF COMPLIANCE (Part 1 of 2) MECH-1

PROJECT NAME		DATE
PROJECT ADDRESS		
PRINCIPAL DESIGNER-MECHANICAL	TELEPHONE	Building Permit #
DOCUMENTATION AUTHOR	TELEPHONE	Checked by/Date Enforcement Agency Use

GENERAL INFORMATION

DATE OF PLANS	BUILDING CONDITIONED FLOOR AREA

BUILDING TYPE ☐ NONRESIDENTIAL ☐ HIGH RISE RESIDENTIAL ☐ HOTEL/MOTEL GUEST ROOM

PHASE OF CONSTRUCTION ☐ NEW CONSTRUCTION ☐ ADDITION ☐ ALTERATION ☐ UNCONDITIONED (file affidavit)

METHOD OF MECHANICAL COMPLIANCE ☐ PRESCRIPTIVE ☐ PERFORMANCE

PROOF OF ENVELOPE COMPLIANCE ☐ PREVIOUS ENVELOPE PERMIT ☐ ENVELOPE COMPLIANCE ATTACHED

STATEMENT OF COMPLIANCE

This Certificate of Compliance lists the building features and performance specifications need to comply with Title 24, Parts 1 and 6 of the California Code of Regulations. This certificate applies only to building mechanical requirements.

The documentation preparer hereby certifies that the documentation is accurate and complete.

DOCUMENTATION AUTHOR	SIGNATURE	DATE

The Principal Mechanical Designer hereby certifies that the proposed building design represented in this set of construction documents is consistent with the other compliance forms and worksheets, with the specifications, and with any other calculations submitted with this permit application. The proposed building has been designed to meet the mechanical requirements contained in the applicable parts of Sections 110 through 115, 120 through 124, 140 through 142, 144 and 145.

Please check one:

☐ I hereby affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code to sign this document as the person responsible for it's preparation; and that I am licensed in the State of California as a civil engineer or mechanical engineer, or I am a licensed architect.

☐ I affirm that I am eligible under the exemption to Division 3 of the Business and Professions Code by Section 5537.2 or 6737.3 to sign this document as the person responsible for its preparation; and that I am a licensed contractor performing this work.

☐ I affirm that I am eligible under the exemption to Division 3 of the Business and Professions Code to sign this document because it pertains to a structure or type of work described pursuant to Business and Professions Code sections 5537, 5538, and 6737.1.

(These sections of the Business and Professions Code are printed in full in the Nonresidential Manual.)

PRINCIPAL MECHANICAL DESIGNER-NAME	SIGNATURE	DATE	LIC. #

MECHANICAL MANDATORY MEASURES

Indicate location on plans of Note Block for Mandatory Measures ______________________

INSTRUCTIONS TO APPLICANT

For Detailed instructions on the use of this and all Energy Efficiency Standards compliance forms, please refer to the Nonresidential Manual published by the California Energy Commission.
MECH-1: Required on plans for all submittals. Part 2 may be incorporated in schedules on plans.
MECH-2: Required for all submittals, but may be incorporated in schedules on plans.
MECH-3: Required for all submittals unless required ventilation rates and airflows are shown on plans, See 4.3.4.
MECH-4: Required for all prescriptive submittals.

CERTIFICATE OF COMPLIANCE (Part 2 of 2) MECH-1

PROJECT NAME	DATE

SYSTEM FEATURES

SYSTEM NAME		MECHANICAL SYSTEMS						NOTE TO FIELD Bldg. Dept. Use
TIME CONTROL								
SETBACK CONTROL								
ISOLATION ZONES								
HEAT PUMP THERMOSTAT?								
ELECTRIC HEAT?								
FAN CONTROL								
VAV MINIMUM POSITION CONTROL?								
SIMULTANEOUS HEAT/COOL?								
HEAT AND COOL SUPPLY RESET?								
VENTILATION								
OUTDOOR DAMPER CONTROL?								
ECONOMIZER TYPE								
DESIGN O.A. CFM (MECH-3, COLUMN H)								
HEATING EQUIPMENT TYPE								
HIGH EFFICIENCY?	IF YES ENTER EFF. #							
MAKE AND MODEL NUMBER								
COOLING EQUIPMENT TYPE								
HIGH EFFICIENCY?	IF YES ENTER EFF. #							
MAKE AND MODEL NUMBER								
PIPE INSULATION REQUIRED?								
PIPE TYPE (SUPPLY, RETURN, ETC.)								
HEATING DUCT LOCATION	R-VALUE							
COOLING DUCT LOCATION	R-VALUE							
DUCT TAPE ALLOWED?								

CODE TABLES: Enter code from table below into columns above.

HEAT PUMP THERMOSTAT?	Y: Yes N: No
ELECTRIC HEAT?	
VAV MINIMUM POSITION CONTROL?	
SIMULTANEOUS HEAT/COOL?	
HEAT AND COOL SUPPLY RESET?	
HIGH EFFICIENCY?	
DUCT TAPE ALLOWED?	
PIPE INSULATION REQUIRED?	

TIME CONTROL	SETBACK CTRL.	ISOLATION ZONES	FAN CONTROL
S: Prog. Switch O: Occupancy Sensor M: Manual Timer	H: Heating C: Cooling B: Both	Enter number of Isolation Zones	I: Inlet Vanes P: Variable Pitch V: VFD O: Other C: Curve

VENTILATION	OUTDOOR DAMPER	ECONOMIZER	DESIGN O.A. CFM
B: Air Balance C: Outside Air Cert. M: Outside Air Measure D: Demand Control N: Natural	A: Auto G: Gravity	A: Air W: Water N: Not Required	Enter Design Outdoor Air CFM. Note: This shall be no less than Column H on MECH-3.

4.3.2 MECH-2: Mechanical Equipment Summary

This form is used to summarize all space-conditioning equipment whose efficiency is regulated by either these *Standards* or the *Appliance Efficiency Standards*. Only equipment subject to these regulations should be listed; air handlers, pumps, cooling towers and other unregulated equipment should not be listed. As many copies of this form should be used as are needed to list all equipment.

Note that, while air handlers are not listed on this form, their airflow and fan power consumption must be included on MECH-4.

The designer may elect to include the information on this form as part of Equipment Schedules on the drawings. If so, then this form may be left blank, except for a note identifying the drawing page(s) where this information may be found.

A. Chiller and Tower Summary

1. **EQUIPMENT NAME** lists the equipment tag or other identifier as shown on the drawings. If more than one space-conditioning system is identical, all may be listed on a single line.

2. **EQUIPMENT TYPE** lists the type of chiller. Chiller types include centrifugal or reciprocating.

   a. Centrifugal: Compression refrigeration system using rotary centrifugal compressor.

   b. Reciprocating. Compression refrigeration system using reciprocating positive displacement compressor.

3. **QTY.** is the number of each unique equipment type.

4. **EFFICIENCY** is the efficiency at the test conditions as specified in Appendix B, Table B-9, Minimum Mechanical Equipment Efficiencies.

5. **TONS** is the equipment capacity (12,000 Btu is equivalent to 1 ton).

6. **PUMPS**

   a. **TOT. QTY** is the number of pumps.

   b. **GPM** is the flow rate in gallons per minute.

   c. **BHP** is the pump brakehorsepower.

   d. **MOTOR EFFICIENCY** is from equipment information or from Appendix B, Table B-8.

   e. **DRIVE EFFICIENCY** default values are 1.0 for a direct drive and 0.97 for a belt drive. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device's efficiency.

   f. **PUMP CONTROL** is the control type, which is either variable flow, riding curve or two speed/stages).

B. DHW/Boiler Summary

1. **SYSTEM NAME** lists the equipment tag or other identifier as shown on the drawings. If more than one space-conditioning system is identical, all may be listed on a single line.

2. **SYSTEM TYPE** includes:

   a. Boilers: electric, fossil fuel, natural draft, forced/induced draft or hot water.

   b. Water Heaters: electric or gas.

3. **DISTRIBUTION TYPE** is standard or recirculating.

4. **QTY.** is the number of individual boilers or tanks in the system.

5. **RATED INPUT** is the rated input capacity listed in certification information for the water heater (in Btu/hr).

6. **VOL. (GALS.)** is volume in gallons of the water heater or storage tank.

7. **ENERGY FACTOR OR RECOVERY EFFICIENCY** is the efficiency of the water heater tank. If water heating is provided by a boiler, the efficiency (thermal efficiency) must include the effects of the storage tank. All efficiencies shall be in accordance with Table B-9 in Appendix B

8. **STANDBY LOSS OR PILOT ENERGY** is standby loss for large (greater than 75,000 Btu/hr) or pilot energy (in Btu/hr) for instantaneous water heaters and large storage (boiler) gas heater type. Enter 0 for no pilot, or 800 if pilot exists.

9. **TANK INSUL.** is the external R-value of insulation on an unfired storage tank.

C. Central System Ratings

1. **SYSTEM NAME** lists the equipment tag or other identifier as shown on the drawings. If more than one space-conditioning system is identical, all may be listed on a single line.

2. **SYSTEM TYPE** is furnace, heat pump, hydronic or Direct expansion (DX) compressors.

3. **QUANTITY** is the number of unique system types.

4. **HEATING**

   a. **OUTPUT** is the heating capacity in Btu/hr at the design conditions. When using the Prescriptive Approach, this number must not exceed the maximum adjusted load (last line of **2. Sizing**) as calculated on MECH-4, unless an exception was taken on that form. It should also be consistent with the total capacity as indicated on MECH-4.

   b. **AUX. kW** is any auxiliary or supplemental electric heating (in kW) which is typically installed in a Heat Pump system.

   c. **EFFICIENCY** is the efficiency at the test conditions as specified in Appendix B, Table B-9, Minimum Mechanical Equipment Efficiencies.

5. **COOLING**

   a. **OUTPUT** is the cooling capacity in Btu/hr at the design conditions. When using the Prescriptive Approach, this number must not exceed the maximum adjusted load (last line of **2. Sizing**) as calculated on MECH-4, unless an exception was taken on that form. It should also be consistent with either the sensible or total capacity as indicated on MECH-4.

   b. **SENSIBLE** is sensible cooling capacity at the design conditions, based on equipment manufacturer's ratings.

   c. **EFFICIENCY** is the efficiency at the test conditions as specified in Appendix B, Table B-9, Minimum Mechanical Equipment Efficiencies.

   d. **ECONOMIZER TYPE** is used for space-conditioning equipment to indicate an air or water economizer. An economizer is not required for chillers.

D. Central Fan Summary

1. **SYSTEM NAME** lists the equipment tag or other identifier as shown on the drawings. If more than one space-conditioning system is identical, all may be listed on a single line.

2. **FAN TYPE** may be constant volume, inlet vane, discharge damper or variable speed, and is used to document compliance with the fan power requirements of Section 144(c) of the *Standards.*

3. **SUPPLY FAN**

   a. **MOTOR LOCATION** is in airstream or outside airstream.

b. **CFM** is the airflow at the design conditions. When using the Prescriptive Approach, this number must match the cfm listed for the supply fan on form MECH-4,**FAN POWER CONSUMPTION**, Column G.

c. **BHP** is supply fan brakehorsepower (see Section 4.2.2.C). When using the Prescriptive Approach, this number must be listed on form MECH-4,**FAN POWER CONSUMPTION**, Column B.

d. **MOTOR EFFICIENCY** is from equipment information or from Appendix B, Table B-8.

e. **DRIVE EFFICIENCY** default values are 1.0 for a direct drive and 0.97 for a belt drive. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device's efficiency.

4. **RETURN FAN** information includes fan CFM, brakehorsepower, and motor and drive efficiency (see SUPPLY FAN above and Section 4.2.2.C).

   a. **CFM** is the airflow at the design conditions.

   b. **BHP** is return fan brake horsepower (see Section 4.2.2.C). When using the Prescriptive Approach, this number must be listed on form MECH-4,**FAN POWER CONSUMPTION**, Column B.

   c. **MOTOR EFFICIENCY** is from equipment information or from Appendix B, Table B-8.

   d. **DRIVE EFFICIENCY** default values are 1.0 for a direct drive and 0.97 for a belt drive. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device's efficiency.

E. VAV Summary

1. **ZONE NAME** lists the equipment tag or other identifier as shown on the drawings.

   If more than one space-conditioning system is identical, all may be listed on a single line.

2. **VAV**

   a. **SYSTEM TYPE** is CAV, VAV, VAV with series fan or VAV with parallel fan, and is used to specify the type of VAV box, and what type of fan is included.

   b. **QUANTITY** is the total number of identical VAV boxes.

   c. **MINIMUM CFM RATIO** is the minimum design air flow rate, which is used to document compliance with Section 144(d) of the *Standards*.

   d. **REHEAT COIL**

   - **TYPE** is hot water or electric. Note that when using the Prescriptive Approach, electric reheat is only allowed as listed under Section 144(g) of the *Standards.*
   - **DELTA T** is the temperature difference at which heat is supplied.

3. FAN

   a. **FLOW RATIO** is used to specify the ratio of airflow in a Parallel Fan or Series Fan powered VAV box.

   b. **CFM** is the total airflow at the design conditions for a fan powered VAV box.

   c. **BHP** is supply fan brakehorsepower (see Section 4.2.2.C). When using the Prescriptive Approach, this number must be included on form MECH-4,**FAN POWER CONSUMPTION**, Column B.

   d. **MOTOR EFFICIENCY** is from equipment information or from Appendix B, Table B-8.

   e. **DRIVE EFFICIENCY** default values are 1.0 for a direct drive and 0.97 for a belt drive. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device’s efficiency.

f. **BASEBOARD TYPE AND OUTPUT**

F. Exhaust Fan Summary

1. **ROOM NAME** lists the equipment tag or other identifier as shown on the drawings. If more than one space-conditioning system is identical, all may be listed on a single line.

2. **QTY** is the total number of identical exhaust fans.

3. **CFM** is the total airflow at the design conditions for an exhaust fan.

4. **BHP** is the exhaust fan brake horsepower (see Section 4.2.2.C). When using the Prescriptive Approach, this number must be included on form MECH-4,**FAN POWER CONSUMPTION**, Column B.

5. **MOTOR EFF.** is from equipment information or from Appendix B, Table B-8.

6. **DRIVE EFF.** default values are 1.0 for a direct drive and 0.97 for a belt drive. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device’s efficiency.

F. Sample Form: MECH-2 Mechanical Equipment Summary

MECHANICAL EQUIPMENT SUMMARY (Part 1 of 2) MECH-2

PROJECT NAME	DATE

CHILLER AND TOWER SUMMARY

					PUMPS					
Equipment Name	Equipment Type	Qty.	Efficiency	Tons	Total Qty.	GPM	BHP	Motor Eff.	Drive Eff.	Pump Control

DHW / BOILER SUMMARY

System Name	System Type	Distribution Type	Qty.	Rated Input	Vol. (Gals.)	Energy Factor or Recovery Efficiency	Standby Loss or Pilot	TANK INSUL. External R-Val

CENTRAL SYSTEM RATINGS

			HEATING			COOLING			
System Name	System Type	Qty.	Output	Aux. kW	Efficiency	Output	Sensible	Efficiency	Economizer Type

CENTRAL FAN SUMMARY

			SUPPLY FAN				RETURN FAN			
System Name	Fan Type	Motor Location	CFM	BHP	Motor Eff.	Drive Eff.	CFM	BHP	Motor Eff.	Drive Eff.

MECHANICAL EQUIPMENT SUMMARY (Part 2 of 2) MECH-2

PROJECT NAME	DATE

VAV SUMMARY

	VAV					FAN					BASEBOARD	
Zone Name	System Type	Qty.	Min. CFM Ratio	Reheat? Type	Reheat? ΔT	Flow Ratio	CFM	BHP	Motor Eff.	Drive Eff.	Type	Output

EXHAUST FAN SUMMARY

EXHAUST FAN						EXHAUST FAN					
Room Name	Qty.	CFM	BHP	Motor Eff.	Drive Eff.	Room Name	Qty.	CFM	BHP	Motor Eff.	Drive Eff.

4.3.3 MECH-3: Mechanical Ventilation

This form is used to document the design outdoor ventilation rate for each space, and the total amount of outdoor air that will be provided by the space-conditioning or ventilating system. For VAV systems, this form also documents the reduced cfm to which each VAV box must control before allowing reheat.

One copy of this form should be provided for each mechanical system. Additional copies may be required for systems with a large number of spaces or zones. In lieu of this form, the required outdoor ventilation rates and airflows may be shown on the plans.

Note that, in all of the calculations that compare a supply quantity to the REQ'D O.A. quantity, the actual percentage of outdoor air in the supply is ignored.

The design outdoor ventilation rate and air distribution assumptions made in the design of the ventilating system must be documented on the plans. Documentation must be in accordance with Section 10-103 of Title 24.

Areas in buildings for which natural ventilation is used should be clearly designated. Specifications must require that building operating instructions include explanations of the natural ventilation system.

A. Ventilation Calculations

1. **COLUMN A - ZONE/SYSTEM** is the system or zone identifier as shown on the plans.

2. **AREA BASIS -** outdoor air calculations are documented in Columns B, C and D. If a space is naturally ventilated, it should be noted here and the rest of the calculations (Columns B-K) skipped.

   COLUMN B - COND. AREA (SF) is the area in square feet for the SPACE, ZONE, or SYSTEM identified in Column A.

   COLUMN C - CFM PER SF is the minimum allowed outdoor ventilation rate as specified in Table No. 1-F of the *Standards* for the type of use listed.

   COLUMN D - MIN CFM is the minimum ventilation rate calculated by multiplying the COND. AREA in Column B by the CFM PER SF in Column C.

3. **OCCUPANCY BASIS** outdoor air calculations are calculated in Columns E, F and G.

   COLUMN E - NO. OF PEOPLE is determined using one of the methods described in Section 4.2.1.F.

   COLUMN F - CFM PER PERSON is determined using one of the methods described in Section 4.2.1.F.

   COLUMN G - MIN CFM is the NO. OF PEOPLE multiplied by CFM PER PERSON.

4. **COLUMN H - REQ'D O.A.** is the larger of the outdoor ventilation rates calculated on an AREA BASIS or OCCUPANCY BASIS (Column D or G).

5. **COLUMN I - DESIGN OUTDOOR AIR CFM** is the actual outdoor air quantity to be provided based on cooling loads. If this quantity is less than the REQ'D O.A., then TRANSFER AIR (Column K) will have to make up the difference.

6. **VAV MIN. CFM** calculations are made for variable air volume systems only, in Column J.

   COLUMN J - VAV MIN. CFM is the maximum airflow to which the VAV box supply must be reduced before reheat is permitted. It is calculated as the largest of:

   a. design fan supply cfm (MECH-2, Part 2) x 30%; or

   b. cond. area (sf) x 0.4 cfm/sf; or

   c. 300 cfm

7. **COLUMN K - TRANSFER AIR** is the amount of air that must be directly transferred from another space so that the space supply is always no less than REQ'D O.A. It is calculated as the largest of:

   a. REQ'D O.A. - DESIGN Outdoor Air (Column H - I); or

   b. REQ'D O.A. - VAV MIN. CFM for a VAV system (Column H - J); or

   c. 300 cfm

   In these calculations, the actual percentage of outside air in the supply is ignored.

TOTALS are summed for

a. **NO. OF PEOPLE** - This value should match the number people used in the load calculations as summarized in the SIZING AND EQUIPMENT SELECTION on MECH-4.

b. **REQ'D O.A.** - The values listed for the system on MECH-1 Design OUTDOOR AIR CFM be at least this amount. The designer may elect to use a greater amount of outdoor air judged necessary to ensure indoor air quality.

c. **DESIGN OUTDOOR AIR** - This value should match any amounts listed for cooling equipment sizing on MECH-4 CFM.

B. Sample Form: MECH-3 Mechanical Ventilation

MECHANICAL VENTILATION MECH-3

PROJECT NAME	DATE

MECHANICAL VENTILATION

A	B	C	D	E	F	G	H	I	J	K
	AREA BASIS			OCCUPANCY BASIS			REQ'D.	DESIGN		
ZONE/ SYSTEM	COND AREA (SF)	CFM PER SF	MIN. CFM (B X C)	NO. OF PEOPLE	CFM PER PERSON	MIN. CFM (E X F)	O.A. (MAX. OF D OR G)	OUTDOOR AIR CFM	VAV MIN. CFM	TRANSFER AIR CFM
	Totals (For MECH-4)									

- **C** Minimum ventilation rate per Section § 121, Table 1-F.
- **E** Based on expected number of occupants or at least 50% of Chapter 10 1997 UBC occupant density
- **I** Must be greater than or equal to H, or use Transfer Air. Design outdoor air includes ventilation from supply air system & exhaust fans which Operate at design conditions.
- **K** Must be greater than or equal to (H - I), and, for VAV, greater than or equal to (H - J).

4.3.4 MECH-4: Mechanical Sizing and Fan Power

This form is used to document the calculations used in sizing equipment and demonstrating compliance with the fan power requirements when using the Prescriptive Approach. The PROJECT NAME, DATE, SYSTEM NAME and FLOOR AREA served by this system should be entered at the top of the form. One form should be provided for each space-conditioning system.

A. Sizing and Equipment Selection

Separate columns are provided for heating and cooling load documentation. The actual load calculations should not be submitted with this form unless requested by the Building Department.

1. **DESIGN CONDITIONS** documents the outdoor and indoor temperature and humidity conditions used in the load calculations. These temperatures should be taken from ASHRAE publication SPCDX for the building location as described in Section 4.2.2B and found in Appendix C.

   OUTDOOR DRY BULB TEMPERATURE for cooling must be no greater than listed in the Summer Design Dry Bulb 0.5% column. Heating should be no less than the temperature listed in the Winter Median of Extremes.

   OUTDOOR WET BULB TEMPERATURE for cooling must be no greater than the Summer Design Wet Bulb 0.5% column. The heating entry is not used.

   INDOOR DRY BULB TEMPERATURE must be determined in accordance with ANSI/ASHRAE 55-1992, or Chapter 8 of the *ASHRAE Handbook, 1993 Fundamentals Volume*. Winter humidification and summer dehumidification are not required.

2. **SIZING** summarizes the major categories of building loads, as determined by the designer in the load calculations, based on the design conditions.

DESIGN OUTDOOR AIR lists the design outdoor quantity determined on form MECH-3, Column I and the corresponding heating and cooling loads. The design outdoor air in Kbtu/h must be calculated in accordance with the procedures described in Chapter 8 of the ASHRAE Handbook, 1993 Fundamentals. The calculations may be done by hand or by a computer program. To calculate use the following equation for cooling and heating as follows:

$$(\Delta T \times DOA \times 1.08) \quad \text{in } \frac{BTU\text{-}^{o}F}{HR}$$

Where;

ΔT = Temperature change between dry bulb and indoor dry bulb temperature for cooling and heating on MECH-4 in ^{o}F.

DOA = Design Outside Air (From MECH-3, Column I) in CFM

1.08 = Conversion factor from CFM to KBTU/Hr.

ENVELOPE LOAD summarizes the heat gains and losses through the building envelope, including conduction, solar radiation and infiltration. These loads must be determined using the surface areas and envelope characteristics as documented on form ENV-2, Part 2 of 5, Column E.

The envelope load in kBtu/h must be calculated in accordance with the procedures described in Chapter 8 of the ASHRAE Handbook, 1993 Fundamentals Volume. The calculations may be done as follows:

$$UA \times \Delta T \text{ in } \frac{BTU\text{-}^{o}F}{HR}$$

Where:

U = U-Value of ech proposed assembly in BTU/Hr – SF.

A = Surface area of each proposed assembly in SF.

ΔT = Temperature change between dry bulb and indoor dry bulb temperature for cooling and heating on MECH- 4 in ^{o}F.

LIGHTING lists the average Watt/sf power density for the spaces served by this system, as documented on form LTG-2, Adjusted Actual Watts. The calculations may be made by taking. The cooling loads for lighting in kBtu/h must be calculated in accordance with the procedures described in Chapter 26 of the ASHRAE Handbook, 1993 Fundamentals Volume. The calculations may be done by hand (watts/sf x 3.41) or by a computer program which uses these procedures. Lighting is disregarded for heating calculations.

PEOPLE lists the number of people as documented on Form MECH-3, and the cooling loads based on the expected activities. The cooling loads for people in kBtu/h must be calculated in accordance with the procedures described in Chapter 26 of the ASHRAE Handbook, 1993 Fundamentals Volume. The calculations may be done by hand or by a computer program which uses these procedures. People loads are disregarded for heating calculations.

MISCELLANEOUS EQUIPMENT lists the average Watts/sf power density for miscellaneous equipment that contributes to cooling loads. The cooling loads for miscellaneous equipment in kBtu/h must be calculated in accordance with the procedures described in Chapter 26 of the ASHRAE Handbook, 1993 Fundamentals Volume. The calculations may be done by (watts/sf x 3.41) or by a computer program. Equipment loads are disregarded for heating calculations.

OTHER lists any other loads, such as process loads, duct loss and infiltration. The amount should be listed, and the load described. The miscellaneous equipment loads in kBtu/h must be calculated in accordance with the procedures described in Chapter 26 of the ASHRAE Handbook, 1993 Fundamentals Volume. The calculations may be done by hand or by a computer program which uses these procedures.This space should also be used for documenting latent loads that are used in selecting the equipment if the selection is based on latent load, rather than sensible load.

OTHER LOADS and SAFETY FACTOR. The designer is allowed to increase the cooling load by 10 percent and the heating load by 30 percent to account for “Other Loads” such as warm-up and cool-down. The designer is also allowed to increase both heating and cooling loads by an additional 10 percent “Safety Factor” to account for unexpected loads. Therefore, the maximum allowed overall factor is (1.10×1.10) or 1.21 for cooling, and (1.10×1.30) or 1.43 for heating.

3. **SELECTION** summarizes how the load calculations are used to select the equipment size

   MAXIMUM ADJUSTED LOAD is the cooling and heating loads, adjusted by Other Loads and the Safety Factor. This is usually the sensible load unless latent loads were used in the equipment selection. If latent loads were used, this entry should be the total sensible and latent load.

   INSTALLED EQUIPMENT CAPACITY lists the cooling and heating capacity of the equipment at the design conditions. If the equipment selection is based on sensible load only, the sensible capacity of the equipment is listed here. If equipment selection is based on total load, the total load should be listed here. If the installed capacity is larger than the maximum adjusted load, the designer should explain the exception taken.

B. Fan Power Consumption

This section is used to show how the fans associated with the space-conditioning system comply with the maximum fan power requirements. All supply, return, exhaust fans, and space exhaust fans – such as toilet exhausts – in the space-conditioning system that operate during the peak design period must be listed. Included are supply/return/exhaust fans in packaged equipment. Economizer fans that do not operate at peak are excluded. Also excluded are all fans that are manually switched and all fans that are not directly associated with moving conditioned air to/from the space-conditioning system, such as condenser fans and cooling tower fans.

If the total horsepower of all fans in the system is less than 25 HP, then this should be noted in the **FAN DESCRIPTION** column and the rest of this section left blank. If the total system horsepower is not obvious, such as when a VAV system has many fan-powered boxes, then this section must be completed.

1. **COLUMN A - FAN DESCRIPTION** lists the equipment tag or other name associated with each fan.

2. **COLUMN B - DESIGN BRAKE HORSEPOWER** lists the brake horsepower, excluding drive losses, as determined from manufacturer's data.

   For dual-fan, dual-duct systems, the heating fan horsepower may be the (reduced) horsepower at the time of the cooling peak. If unknown, it may be assumed to be 35 percent of design. If this fan will be shut down during the cooling peak, enter 0 in Column B.

   If the system has fan-powered VAV boxes, the VAV box power must be included if these fans run during the cooling peak. The power of all boxes may be summed and listed on a single line. If the manufacturer lists power consumption in watts, then the wattage sum may be entered directly in Column F. Horsepower must still be entered in Column B if the designer intends to show that total system has less than 25 HP.

3. **COLUMNS C & D - EFFICIENCY** lists the efficiency of the **MOTOR** and **DRIVE**. The default for a direct drive is 1.0; belt drive is 0.97. If a variable-speed or variable-frequency drive is used, the drive efficiency should be multiplied by that device's efficiency.

4. **COLUMN E - NUMBER OF FANS** lists the number of identical fans included in this line.

   COLUMN F - PEAK WATTS is calculated as:

   (BHP x Number x 746W/HP)$(E_m \times E_d)$

   where E_m and E_d are the efficiency of the motor and the drive, respectively.

5. **COLUMN G - CFM** is the design supply airflow at the cooling peak. This field is left blank for return fans, exhaust fans, or other fans that do not add to the net air supply to a space. (Note that power consumption for returns and exhausts is accounted for in Column B).

   For dual-duct systems, the airflow must include the hot deck airflow at the time of the cooling peak. For VAV systems with fan powered boxes, the airflow of the box fan may or may not be allowable depending on the configuration (see Section 4.2.2C).

6. **TOTALS** are provided for both PEAK WATTS (Column F) and CFM (Column G).

7. **TOTAL FAN SYSTEM POWER DEMAND, WATTS/CFM** is calculated by dividing the total PEAK WATTS (Column F) by the total CFM (Column G). To comply, total space-conditioning system power demands must not exceed 0.8 W/cfm for constant volume systems, or 1.25 W/cfm for VAV systems.

C. Sample Form: MECH-4 Mechanical Sizing and Fan Power

MECHANICAL SIZING AND FAN POWER — MECH-4

PROJECT NAME	DATE
SYSTEM NAME	FLOOR AREA

NOTE: Provide one copy of this form for each mechanical system when using the Prescriptive Approach.

SIZING and EQUIPMENT SELECTION

			COOLING	HEATING
1. DESIGN CONDITIONS:				
- OUTDOOR, DRY BULB TEMPERATURE		(APPENDIX C)		
- OUTDOOR, WET BULB TEMPERATURE		(APPENDIX C)		
- INDOOR, DRY BULB TEMPERATURE		(See Chap. 8, ASHRAE handbook, 1993)		
2. SIZING				
- DESIGN OUTDOOR AIR		CFM (MECH 3; COLUMN I)		
- ENVELOPE LOAD		Btu/Hr (ENV-2 Part 2 of 5 Column E)		
- LIGHTING		W / SF (Adjusted Actual Watts-LTG-2)		
- PEOPLE		# OF PEOPLE (MECH 3; COLUMN E)		
- MISCELLANEOUS EQUIPMENT		WATTS / SF		
- OTHER				
1)				
2)				
3)				
		TOTALS		
OTHER LOADS/SAFETY FACTOR (1.21 for cooling, 1.43 for heating)				
MAXIMUM ADJUSTED LOAD (TOTALS FROM ABOVE x OTHER LOAD SAFETY FACTOR)				

3. SELECTION:

	COOLING	HEATING
INSTALLED EQUIPMENT CAPACITY	KBtu / Hr	KBtu / Hr

IF INSTALLED CAPACITY EXCEEDS MAXIMUM ADJUSTED LOAD, EXPLAIN ______________________________

FAN POWER CONSUMPTION

A	B	C	D	E	F	G
FAN DESCRIPTION	**DESIGN BRAKE HP**	**EFFICIENCY** MOTOR	**EFFICIENCY** DRIVE	**NUMBER OF FANS**	**PEAK WATTS** B x E x 746 / (C x D)	**CFM** (Supply Fans)
				TOTALS		

NOTE: Include only fan systems exceeding 25 HP (see § 144). Total Fan System Power Demand may not exceed 0.8 Watts/CFM for constant volume systems or 1.25 Watts/CFM for VAV systems.

TOTAL FAN SYSTEM POWER DEMAND WATTS / CFM ______ Col. F / Col. G

4.4 MECHANICAL INSPECTION

The mechanical building inspection process for energy compliance is carried out along with the other building inspections performed by the building department. The inspector relies upon the plans and upon the MECH-1 Certificate of Compliance form printed on the plans (See Section 4.3.1). Included on the MECH-1 are “Notes to Field” that are provided by the plan checker to alert the inspector to items of special interest for field verification.

To assist in the inspection process, an Inspection Checklist is provided in Appendix I.

Chapter 4 Index

A

AFUE · 3, 4, 9, 65
Agricultural · 59, 60
Air Balance · 65
Air Delivery Systems · 6
Air Economizer · 6, 7
Air Mixing · 1, 6
Airflow · 11
Alterations · 1, 42
Alternative Calculation Methods Approval Manual · 42
Annual Fuel Utilization Efficiency · 3
Apartments · 13, 14
Appliance Efficiency Regulations · 3, 4, 9, 10, 62
Application · 1, 42
Arcades · 14
Area · 2, 13, 14
Arenas · 14
ARI · 9, 64
ASHRAE 62-1989 · 15
ASHRAE Handbook · 29, 30, 32, 33, 78, 79
Assembly · 13, 14
Associated Air Balance Council · 20, 62
Attics · 1, 6
Auditoriums · 13, 14
Automatic Time · 23

B

Balancing · 17, 20, 62
Bank/Financial Institution · 14
Bars · 11, 14
Basements · 13
Beauty Shops · 14
Boilers · 69
Building · 12, 13, 15, 20, 78
Building Department · 78
Business and Professions Code · 59

C

California Code of Regulations · 9, 59
California Safety Code · 20, 62
Central Plant · 26, 54, 55
Certificate of Compliance · 57, 59, 66, 67, 68, 82
Changeover Systems · 19
Churches · 13, 14
Circulating Systems · 30
Classroom · 15
Climate · 42
Coefficient of Performance · 3
Combustion Efficiency · 3, 9
Commercial · 11, 13, 14
Compliance · 1, 9, 10, 42
Components · 1, 42
Computer · 1, 34, 42
Computer Method · 1, 42
Concepts · 39
Conference Rooms · 14
Constant Volume · 6
Contaminants · 1
Control Equipment Certification · 10
Controls · 1, 3, 9, 10, 17, 21, 24, 29, 32, 37, 40, 61, 62
Convention · 14
Cooling · 3, 33, 52, 64
Corridors · 14

D

Dampers · 20, 24, 53, 55
DATE OF PLANS · 58
Definitions of Efficiency · 1, 3
Demand Control Ventilation · 1, 8, 19
Dining Rooms · 13, 14
Direct Air Transfer · 16
Distribution of Outdoor Air · 16
Documentation · 59, 75
Documentation Author · 59
Duct Insulation · 29
Ducts · 1, 9, 28, 45, 48, 51, 55, 57

E

Economizer · 7, 8, 39, 79
Electric Resistance · 1
Energy Efficiency Ratio · 4
Energy Factor · 4
ENV-1 · 58
ENV-2 · 78
Equipment Certification · 1, 9
Equipment Schedules · 69
Equipment Sizing · 32
Exhaust Air · 5

F

Fan Coils · 24
Fan Cycling · 19
Fan Power · 1, 4, 34, 37, 51, 57, 78, 79, 80, 81
Fan Power Consumption · 1, 34, 79

MECH

Field-Fabricated · 28
Fire and Life Safety · 26
Floors · 13, 14

G

Garages · 59, 60
Gas Furnace · 43, 65
Guest Room · 14, 22

H

Heat Pump · 41, 43, 52, 55, 62, 70
Heating · 1, 3, 9, 20, 31, 33, 41, 43, 44, 46, 47, 50, 52, 53, 55, 57, 64, 78
High-Rise Residential · 22
Hotel Function Area · 14
Hotel Lobby · 14
Hotel/Motel · 22

I

Industrial · 14
Inspection · 1, 2, 82
Installation · 28
Insulation · 1, 27, 28
Integrated Part Load Value · 4
Isolation Area Devices · 25
Isolation of Central Air Systems · 25
Isolation Zones · 25

K

Kitchens · 13

L

Lavatories · 30, 63
Lighting · 33, 79
Load Calculations · 1, 32
LTG-2 · 79

M

Malls · 13, 14
Mandatory Measures · 1, 8, 60
Manufacturers · 10
MECH-1 · 1, 57, 66, 67, 68, 76, 82
MECH-2 · 1, 57, 65, 69, 72, 73, 74, 75
MECH-3 · 1, 57, 65, 75, 76, 77, 78, 79
MECH-4 · 1, 57, 69, 70, 71, 72, 76, 78, 80, 81
Mechanical Compliance Approaches · 2
Mechanical Concepts · 1, 3
Mechanical Equipment · 13, 14, 57, 69, 70, 72, 73, 74
Mechanical Equipment Summary · 57, 69, 72, 73, 74
Mechanical Mandatory Measures · 60, 61
Mechanical Systems · 1
Mechanical Ventilation · 1, 12, 57, 75, 76, 77
Medical · 14
Mixed Air · 5
Modeling · 1, 42

N

National Electric Code · 31
National Environmental Balancing Bureau · 20, 62
Natural Ventilation · 1, 11, 18, 65
Notes to Field · 82
Nurseries · 14

O

Occupancy · 10, 14, 18, 23, 42, 64
Occupancy Sensors · 10
Offices · 13, 14, 19
Optimized Start · 19
Orientation · 42
Outdoor Air · 5, 33, 76
Outdoor Ventilation · 1, 10, 16
Outside Air Certification · 20, 62, 65
Outside Air Measurement · 20, 62

P

Packaged Air Conditioner · 43
Performance Approach · 1, 41
PHASE OF CONSTRUCTION · 58
Pilot Lights · 1, 9, 10
Pipe Insulation · 9, 26, 27
Plenum · 6, 28, 66
Pool · 1, 9, 10, 13, 14, 31, 63
Prescriptive Approach · 1, 31, 70, 71, 72, 78
Pressure Dependent · 6
Pressure Independent · 6
Purge · 18, 25

R

Recooling · 6, 37
Refrigeration · 9, 64

Reheating · 37
Repair · 14
Retail · 13, 14
Return Air · 5, 6
R-value · 26, 30, 63, 66, 70

S

Safety Factor · 79
Seasonal Energy Efficiency Ratio · 4
Service Water Heating · 1, 9, 30, 41, 62
Setback · 22, 24
Shut-off · 21, 22
Smoking Lounges · 14
Sources of Contaminants · 8
Space Conditioning · 4, 5, 9, 21, 37
Space Conditioning System · 5, 9, 21
Space Conditioning Zone · 37
Specifications · 75
State Building · 31
Statement of Compliance · 59
Storage Tank Insulation · 30
Summer Design Dry Bulb · 23, 33, 78
Summer Design Wet Bulb · 33, 78
Supply Air · 5, 12, 40
Supply Air Reset · 40
Swimming Pool · 13, 14

T

Theaters · 14
Thermal Efficiency · 4, 9
Thermostats · 2, 21, 22, 62
Time Control · 24
Transfer Air · 6
Types of Air · 1, 5
Typical Building Energy Use · 2

U

UBC · 12, 13, 14

V

Variable Air Volume · 6, 19, 35
VAV Box · 6
VAV Systems · 16
Ventilation · 1, 2, 9, 10, 12, 14, 15, 16, 19, 20, 33, 43, 44, 46, 49, 51, 52, 53, 54, 55, 56, 62, 75
Ventilation Rate · 12, 14, 19
Ventilation System Operation and Controls · 16

W

Warehouses · 13, 14
Water Heaters · 31, 69
Wholesale · 14

Z

Zonal Systems · 25
Zone Controls · 1, 38, 44, 46, 49, 52, 53, 54, 56
Zone Reheat · 1, 6
Zone Thermostatic Control · 21